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MANUAL OF OPERATIVE SURGERY

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MANUAL
OF
OPERATIVE SURGERY

BY

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PREFACE TO SIXTH EDITION

THIS edition has been generally revised. A number of operations not included previously have been inserted and some operations which are more or less obsolete have been omitted.

I again gratefully acknowledge the very kind interest and criticism of many Surgeons, Professors, Lecturers, and Teachers of Operative Surgery both at home and abroad where the work is used.

The chapters on Diseases of the Nose and Larynx have been revised by Mr. Douglas Harmer, and that on Ophthalmic Operations by Mr. Foster Moore. Mr. H. E. Griffiths, Demonstrator of Anatomy and Operative Surgery at St. Bartholomew's Hospital Medical College, has given me considerable assistance in the general revision and also in seeing the work through the Press. Mr. Geoffrey Keynes has written the section on Blood Transfusion.

A number of new illustrations have been added. These are the work of Mr. Kirkpatrick Maxwell. I express my gratitude to him for the excellent manner in which he has done them. For the use of illustrations I express my thanks to my friends Professor Arthur Robinson, Sir Charles Ball, Sir James Berry, Mr. Howard Kelly, and Mr. L. B. Rawling.

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H. J. WARING.

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A GLOSSARY
OF THE
INTERNATIONAL (B.N.A.) ANATOMICAL TERMINOLOGY

◆

GENERAL TERMS.

Terms indicating Situation and Direction.

Longitudinalis	Longitudinal	Referring to the long axis of the body.
Verticalis	Vertical	Referring to the position of the long axis of the body in the erect posture.
Anterior	Anterior	Referring to the front and back of the body or the limbs.
Posterior	Posterior	
Ventral	Ventral	Referring to the anterior and posterior aspects, respectively, of the body, and to the flexor and extensor aspects of the limbs, respectively.
Dorsal	Dorsal	
Cranial	Cranial	Referring to position nearer the head or the tail end of the long axis. Used only in reference to parts of the head, neck, or body.
Caudal	Caudal	
Superior	Superior	Used in reference to the head, neck, and body. Equivalent to cranial and caudal respectively.
Inferior	Inferior	
Proximalis	Proximal	Used only in reference to the limbs. Proximal nearer the attached end. Distal nearer the free end.
Distalis	Distal	
Sagittalis	Sagittal	Used in reference to planes parallel with the sagittal suture of the skull, *i.e.* vertical antero-posterior planes.
Frontalis	Frontal	Used in reference to planes parallel with the coronal suture of the skull, *i.e.* transverse vertical planes.
Horizontalis	Horizontal	Used in reference to planes at right angles to vertical planes.
Medianus	Median	Referring to the median vertical antero-posterior plane of the body.

Medialis	Medial	Referring to structures relatively nearer to or farther away from the median plane.
Lateralis	Lateral	
Intermedius	Intermediate	Referring to structures situated between more medial and more lateral structures.
Superficialis	Superficial	Referring to structures nearer to and farther away from the surface.
Profundus	Deep	
Externus	External	Referring, with few exceptions, to the walls of cavities and hollow organs. *Not* to be used as synonymous with medial and lateral.
Internus.	Internal.	
Ulnaris	Ulnar	Used in reference to the medial and lateral borders of the forearm, respectively.
Radialis	Radial	
Tibial	Tibial	Used in reference to the medial and lateral borders of the leg, respectively.
Fibular	Fibular	

THE BONES.

B.N.A. Terminology.	Old Terminology.
Vertebræ	**Vertebræ**
Fovea costalis superior	Incomplete facet for head of rib, upper
Fovea costalis inferior	Incomplete facet for head of rib, lower
Fovea costalis transversalis	Facet for tubercle of the rib
Radix arcus vertebræ	Pedicle
Atlas	**Atlas**
Fovea dentis	Facet for odontoid process
Epistropheus	**Axis**
Dens	Odontoid process
Sternun	**Sternum**
Corpus sterni	Gladiolus
Processus xiphoideus	Ensiform process
Incisura jugularis	Supra-sternal notch
Planum sternale	Anterior surface

Ossa Cranii.	Bones of Skull
Os frontale	**Frontal**
Spina frontalis	Nasal spine
Processus zygomaticus	External angular process
Facies cerebralis	Internal surface
Facies frontalis	Frontal surface
Os Oparietale	**Parietal**
Lineæ temporales	Temporal ridges
Sulcus transversus	Groove for lateral sinus
Sulcus sagittalis	Groove for sup. long. sinus

B.N.A. Terminology.	Old Terminology.
Os occipitale	**Occipital**
Canalis hypoglossi	Anterior condyloid foramen
Foramen occipitale magnum	Foramen magnum
Canalis condyloideus	Posterior condyloid foramen
Sulcus transversus	Groove for lateral sinus
Sulcus sagittalis	Groove for sup. long. sinus
Clivus	Median part of upper surface of basi-occipital
Linea nuchæ suprema	Highest curved line
Linea nuchæ superior	Superior curved line
Linea nuchæ inferior	Inferior curved line
Os sphenoidale	**Sphenoid**
Crista infratemporalis	Pterygoid ridge
Sulcus chiasmatis	Optic groove
Crista sphenoidalis	Ethmoidal crest
Spina angularis	Spinous process
Lamina medialis processus pterygoidei	Internal pterygoid plate
Lamina lateralis processus pterygoidei	External pterygoid plate
Canalis pterygoideus [Vidii]	Vidian canal
Fossa hypophyseos	Pituitary fossa
Sulcus caroticus	Cavernous groove
Conchæ sphenoidales	Sphenoidal turbinal bones
Hamulus pterygoideus	Hamular process
Canalis pharyngeus	Pterygo-palatine canal
Tuberculum sellæ	Olivary eminence
Fissura orbitalis superior	Sphenoidal fissure
Os temporale	**Temporal Bone**
Canalis facialis [Fallopii]	Aqueduct of Fallopius
Hiatus canalis facialis	Hiatus Fallopii
Vagina processus styloidei	Vaginal process of tympanic bone
Incisura mastoidea	Digastric fossa
Impressio trigemini	Impression for Gasserian ganglion
Eminentia arcuata	Eminence for sup. semicircular canal
Sulcus sigmoideus	Fossa sigmoidea
Fissura petrotympanica	Glaserian fissure
Fossa mandibularis	Glenoid cavity
Semicanalis tubæ auditivæ	Eustachian tube
Os ethmoidale	**Ethmoid**
Labyrinthus ethmoidalis	Lateral mass
Lamina papyracea	Os planum
Processus uncinatus	Unciform process
Os lacrimale	**Lachrymal Bone**
Hamulus lacrimalis	Hamular process
Crista lacrimalis posterior	Lachrymal crest
Os nasale	**Nasal Bone**
Sulcus ethmoidalis	Groove for nasal nerve

B.N.A. Terminology.	Old Terminology.
Maxilla	**Superior Maxillary Bone**
Facies anterior	Facial or external surface
Facies infra-temporalis	Zygomatic surface
Sinus maxillaris	Antrum of Highmore
Processus frontalis	Nasal process
Processus zygomaticus	Malar process
Canales alveolares	Posterior dental canals
Canalis naso-lacrimalis	Lacrimal groove
Os incisivum	Premaxilla
Foramen incisivum	Anterior palatine foramen
Os palatinum	**Palate Bone**
Pars perpendicularis	Vertical plate
Crista conchalis	Inferior turbinate crest
Crista ethmoidalis	Superior turbinate crest
Pars horizontalis	Horizontal plate
Os zygomaticum	**Malar Bone**
Processus temporalis	Zygomatic process
Processus fronto-sphenoidalis	Frontal process
Foramen zygomatico-orbitale	Temporo-malar canal
Foramen zygomatico-faciale	Malar foramen
Mandibula	**Inferior Maxillary Bone**
Spina mentalis	Genial tubercle or spine
Linea obliqua	External oblique line
Linea mylohyoidea	Internal oblique line
Incisura mandibulæ	Sigmoid notch
Foramen mandibulare	Inferior dental foramen
Canalis mandibulæ	Inferior dental canal
Protuberantia mentalis	Mental process

The Skull as a Whole.

Ossa suturarum	Wormian bones
Foveolæ granulares (Pacchioni)	Pacchionian depressions
Fossa pterygo-palatina	Spheno-maxillary fossa
Canalis pterygo-palatinus	Posterior palatine canal
Foramen lacerum	Foramen lacerum medium
Choanæ	Posterior nares
Fissura orbitalis superior	Sphenoidal fissure
Fissura orbitalis inferior	Spheno-maxillary fissure

Upper Extremity.

Clavicle	**Clavicle**
Tuberositas coracoidea	Impression for conoid ligament
Tuberositas costalis	Impression for rhomboid ligamen
Scapula	**Scapula**
Incisura scapularis	Supra-scapular notch
Angulus lateralis	Anterior or lateral angle
Angulus medialis	Superior angle

B.N.A. Terminology.	Old Terminology.
Humerus	**Humerus**
Sulcus intertubercularis	Bicipital groove
Crista tuberculi majoris	External lip
Crista tuberculi minoris	Internal lip
Facies anterior medialis	Internal surface
Facies anterior lateralis	External surface
Margo medialis	Internal border
Margo lateralis	External border
Sulcus nervi radialis	Musculo-spiral groove
Capitulum	Capitellum
Epicondylus medialis	Internal condyle
Epicondylus lateralis	External condyle
Ulna	**Ulna**
Incisura semilunaris	Greater sigmoid cavity
Incisura radialis	Lesser sigmoid cavity
Crista interossea	External or interosseous border
Facies dorsalis	Posterior surface
Facies volaris	Anterior surface
Facies medialis	Internal surface
Margo dorsalis	Posterior border
Margo volaris	Anterior border
Radius	**Radius**
Tuberositas radii	Bicipital tuberosity
Incisura ulnaris	Sigmoid cavity
Crista interossea	Internal or interosseous border
Facies dorsalis	Posterior surface
Facies volaris.	Anterior surface
Facies lateralis	External surface
Margo dorsalis	Posterior border
Margo volaris	Anterior border
Carpus	**Carpus**
Os naviculare	**Scaphoid**
Os lunatum	**Semilunar**
Os triquetrum	**Cuneiform**
Os multangulum majus	**Trapezium**
Os multangulum minus	**Trapezoid**
Os capitatum	**Os magnum**
Os hamatum	**Unciform**

Lower Extremity.

Os coxæ	**Innominate Bone**
Linea glutæa anterior	Middle curved line
Linea glutæa posterior	Superior curved line
Linea terminalis	Margin of inlet of true pelvis
Spina ischiadica	Spine of the ischium
Incisura ischiadica major	Great sacro-sciatic notch
Incisura ischiadica minor	Lesser sacro-sciatic notch
Tuberculum pubicum	Spine of pubis
Ramus inferior oss. pubis	Descending ramus of pubis
Ramus superior oss. pubis	Ascending ramus of pubis
Ramus superior ossis ischii	Body of ischium
Ramus inferior oss. ischii	Ramus of ischium
Pecten ossis pubis	Pubic part of ilio-pectineal line
Facies symphyseos	Symphysis pubis

B.N.A. TERMINOLOGY.	OLD TERMINOLOGY.
Pelvis	**Pelvis**
Pelvis major	False pelvis
Pelvis minor	True pelvis
Apertura pelvis minoris superior	Pelvic inlet
Apertura pelvis minoris inferior	Pelvic outlet
Femur	**Femur**
Fossa trochanterica	Digital fossa
Linea intertrochanterica	Spiral line
Crista intertrochanterica	Post. intertrochanteric line
Condylus medialis	Inner condyle
Condylus lateralis	Outer condyle
Epicondylus medialis	Inner tuberosity
Epicondylus lateralis	Outer tuberosity
Tibia	**Tibia**
Condylus medialis	Internal tuberosity
Condylus lateralis	External tuberosity
Eminentia intercondyloidea	Spine
Tuberositas tibiæ	Tubercle
Malleolus medialis	Internal malleolus
Fibula	**Fibula**
Malleolus lateralis	External malleolus

Bones of the Foot.

Talus	**Astragalus**
Calcaneus	**Os calcis**
Tuber calcanei	Tuberosity of os calcis
Processus medialis tuberis calcanei	Inner } Tuberosities of os calcis
Processus lateralis tuberis calcanei	Outer }
Os cuneiforme primum	**Inner cuneiform**
Os cuneiforme secundum	**Middle cuneiform**
Os cuneiforme tertium	**Outer cuneiform**

THE LIGAMENTS.

Ligaments of the Spine.

Lig. longitudinale anterius	Anterior common ligament
Lig. longitudinale posterius	Posterior common ligament
Lig flava	Ligamenta subflava
Membrana tectoria	Posterior occipito-axial ligament
Articulatio atlanto-epistrophica	Joint between the atlas and the axis
Lig. alaria	Odontoid or check ligaments
Lig. apicis dentis	Suspensory ligament

The Ribs.

Lig. capituli costæ radiatum	Anterior costo-vertebral or stellate ligament
Lig. sterno-costale interarticulare	Interarticular chondro-sternal ligament
Lig. sterno-costalia radiata	Anterior and posterior chondro-sternal ligament
Lig. costoxiphoidea	Chondro-xiphoid ligaments

The Jaw.

B.N.A. TERMINOLOGY.	OLD TERMINOLOGY.
Lig. temporo-mandibulare	External lateral ligament of the jaw
Lig. spheno-mandibulare	Internal lateral ligament of the jaw
Lig. stylo-mandibulare	Stylo-maxillary ligament

Upper Extremity.

Lig. costo-claviculare	Rhomboid ligament
Labrum glenoidale	Glenoid ligament
Articulatio radio-ulnaris proximalis	Superior radio-ulnar joint
Lig. collaterale ulnare	Internal lateral ligament of elbow-joint
Lig. collaterale radiale	External lateral ligament
Lig. annulare radii	Orbicular ligament
Chorda obliqua	Oblique ligament of ulna
Articulatio radio-ulnaris distalis	Inferior radio-ulnar joint
Discus articularis	Triangular fibro-cartilage
Recessus sacciformis	Membrana sacciformis
Lig. radio-carpeum volare	Anterior ligament of the radio-carpal joint
Lig. radio-carpeum dorsale	Posterior ligament of the radio-carpal joint
Lig. collaterale carpi ulnare	Internal lateral ligament of the wrist joint
Lig. collaterale carpi radiale	External lateral ligament of the wrist joint
Articulationes intercarpæ	Carpal joints
Lig. accessoria volaria	Palmar ligaments of the metacarpo-phalangeal joints
Lig. capitulorum (oss. metacarpalium) transversa	Transverse metacarpal ligament
Lig collateralia	Lateral phalangeal ligaments

The Lower Extremity.

Lig. arcuatum	Subpubic ligament
Lig. sacro-tuberosum	Great sacro-sciatic ligament
Processus falciformis	Falciform process
Lig. sacro-spinosum	Small sacro-sciatic ligament
Labrum glenoidale	Cotyloid ligament
Zona orbicularis	Zonular band
Ligamentum iliofemorale	Y-shaped ligament
Lig. ischio-capsulare	Ischio-capsular band
Lig. pubo-capsulare	Pubo-femoral ligament
Lig. popliteum obliquum	Ligament of Winslow
Lig. collaterale fibulare	Long external lateral ligament
Lig. collaterale tibiale	Internal lateral ligament
Lig. popliteum arcuatum	Arcuate popliteal ligament
Meniscus lateralis	External semilunar cartilage
Meniscus medialis	Internal semilunar cartilage
Plica synovialis patellaris	Lig. mucosum
Plicæ alares	Ligamenta alaria
Articulatio tibio-fibularis	Superior tibio-fibular articulation

B.N.A. Terminology.	Old Terminology.
Lig. capituli fibulæ	Anterior and posterior superior tibio-fibular ligaments
Syndesmosis tibio-fibularis	Inferior tibio-fibular articulation
Lig. deltoideum	Internal lateral ligament of ankle
Lig. talo-fibulare anterius	Anterior fasciculus of external lateral ligament
Lig. talo-fibulare posterius	Posterior fasciculus of external lateral ligament
Lig. calcaneo-fibulare	Middle fasciculus of external lateral ligament
Lig. talo-calcaneum laterale	External calcaneo-astragaloid ligament
Lig. talo-calcaneum mediale	Internal calcaneo-astragaloid ligament
Lig. calcaneo-naviculare plantare	Inferior calcaneo-navicular ligament
Lig. talo-naviculare	Astragalo-scaphoid ligament
Pars calcaneo-navicularis } lig. bifurcatum	Superior calcaneo-scaphoid ligament
Pars calcaneo-cuboidea	Internal calcaneo-cuboid ligament

THE MUSCLES.

Muscles of the Back.

Superficial.

Levator scapulæ	Levator anguli scapulæ

Muscles of the Chest.

Serratus anterior	Serratus magnus

Muscles of Upper Extremity.

Biceps brachii	Biceps
Lacertus fibrosus	Bicipital fascia
Brachialis	Brachialis anticus
Triceps brachii	Triceps
Caput mediale	Inner head
Caput laterale	Outer head
Pronator teres	Pronator radii teres
Caput ulnare	Coronoid head
Brachio-radialis	Supinator longus
Supinator	Supinator brevis
Extensor carpi radialis longus	Extensor carpi radialis longior
Extensor carpi radialis brevis	Extensor carpi radialis brevior
Extensor indicis proprius	Extensor indicis
Extensor digiti quinti proprius	Extensor minimi digiti
Abductor pollicis longus	Extensor ossis metacarpi pollicis
Abductor pollicis brevis	Abductor pollicis
Extensor pollicis brevis	Extensor primi internodii pollicis
Extensor pollicis longus	Extensor secundi internodii pollicis
Lig. carpi transversum	Anterior annular ligament
Lig. carpi dorsale	Posterior annular ligament

Muscles of Lower Extremity.

B.N.A. Terminology.	Old Terminology.
Tensor fasciæ latæ	Tensor fasciæ femoris
Canalis adductorius (Hunteri)	Hunter's canal
Trigonum femorale (fossa Scarpæ major)	Scarpa's triangle
Canalis femoralis	Crural canal
Annulus femoralis	Crural ring
M. quadriceps femoris—	Quadriceps—
Rectus femoris	Rectus femoris
Vastus lateralis	Vastus externus
Vastus intermedius	Crureus
Vastus medialis	Vastus internus
M. articularis genu	Subcrureus
Tibialis anterior	Tibialis anticus
Tendo calcaneus	Tendo Achillis
Tibialis posterior	Tibialis posticus
Quadratus plantæ	Accessorius
Lig. transversum cruris	Upper anterior annular ligament
Lig. cruciatum cruris	Lower anterior annular ligament
Lig. laciniatum	Internal annular ligament
Retinaculum musculorum peronæorum superius	External annular ligament
Retinaculum musculorum peronæorum inferius	

Axial Muscles.

Muscles of the Back

Serratus posterior superior	Serratus posticus superior
Serratus posterior inferior	Serratus posticus inferior
Splenius cervicis	Splenius colli
Sacro-spinalis	Erector spinæ
Ilio-costalis—	**Ilio-costalis**—
Lumborum	Sacro-lumbalis
Dorsi	Accessorius
Cervicis	Cervicalis ascendens
Longissimus—	**Longissimus**—
Dorsi	Dorsi
Cervicis	Transversalis cervicis
Capitis	Trachelo-mastoid
Spinalis—	**Spinalis**—
Dorsi	Dorsi
Cervicis	Colli
Capitis	Capitis
Semispinalis—	**Semispinalis**—
Dorsi	Dorsi
Cervicis	Colli
Capitis	Complexus
Multifidus	Multifidus spinæ

Muscles of Head and Neck.

Epicranius	Occipito-frontalis
Galea aponeurotica	Epicranial aponeurosis
Procerus	Pyramidalis nasi
Pars transversa (nasalis)	Compressor naris

B.N.A. TERMINOLOGY.	OLD TERMINOLOGY.
Pars alaris (nasalis)	Dilatores naris
Auricularis anterior	Attrahens aurem
Auricularis posterior	Retrahens aurem
Auricularis superior	Attollens aurem
Orbicularis oculi	Orbicularis palpebrarum
Pars lacrimalis	Tensor tarsi
Triangularis	Depressor anguli oris
Quadratus labii superioris—	
Caput zygomaticum	Zygomaticus minor
Caput infraorbitale	Levator labii superioris
Caput angulare	Levator labii superioris alæque nasi
Zygomaticus	Zygomaticus major
Caninus	Levator anguli oris
Quadratus labii inferioris	Depressor labii inferioris
Mentalis	Levator menti
Platysma	Platysma myoides
Sterno-thyroid	Sterno-thyroid
Thyro-hyoid	Thyro-hyoid

Muscles and Fascia of the Orbit.

Fascia bulbi	Capsule of Tenon
Septum orbitale	Palpebral ligaments
Rectus lateralis	Rectus externus
Rectus medialis	Rectus internus

Muscles of the Tongue.

Genio-glossus	Genio-hyo-glossus
Longitudinalis superior	Superior lingualis
Longitudinalis inferior	Inferior lingualis
Transversus linguæ	Transverse fibres
Verticalis linguæ	Vertical fibres

Muscles of the Pharynx.

Pharyngo-palatinus	Palato-pharyngeus
M. uvulæ	Azygos uvulæ
Levator veli palatini	Levator palati
Tensor veli palatini	Tensor palati
Glosso-palatinus	Palato-glossus

Deep Lateral Muscles of Neck.

Scalenus anterior	Scalenus anticus
Scalenus posterior	Scalenus posticus
Longus capitis	Rectus capitis anticus major
Rectus capitis anterior	Rectus capitis anticus minor

Muscles of Thorax.

Transversus thoracis	Triangularis sterni
Diaphragma pars lumbalis	Diaphragm, lumbar part—
Crus mediale Crus intermedium Curs laterale	Crura and origins from arcuate ligaments
Arcus lumbo - costalis medialis (Halleri)	Ligamentum arcuatum internum
Arcus lumbo - costalis lateralis (Halleri)	Ligamentum arcuatum externum

Muscles of the Abdomen.

B.N.A. TERMINOLOGY.	OLD TERMINOLOGY.
Ligamentum inguinale (Pouparti)	Poupart's ligament
Ligamentum lacunare (Gimbernati)	Gimbernat's ligament
Fibræ intercrurales	Intercolumnar fibres
Ligamentum inguinale reflexum (Collesi)	Triangular fascia
Annulus inguinalis subcutaneus	External abdominal ring
Crus superius	Internal pillar
Crus inferius	External pillar
Falx aponeurotica inguinalis	Conjoined tendon
M. transversus abdominis	Transversalis muscle
Linea semicircularis (Douglasi)	Fold of Douglas
Annulus inguinalis abdominalis	Internal abdominal ring

Perineum and Pelvis.

Transversus perinei superficialis	Transversus perinei
M. sphincter urethræ membranaceæ	Compressor urethræ
Diaphragma urogenitale	Deep transverse muscle and sphincter urethræ
Fascia diaphragmatis urogenitalis superior	Deep layer of triangular ligament
Fascia diaphragmatis urogenitalis inferior	Superficial layer of the triangular ligament
Arcus tendineus fasciæ pelvis	White line of pelvis
Ligamenta puboprostatica	Anterior and lateral true ligaments of bladder
Fascia diaphragmatis pelvis superior	Visceral layer of pelvic fascia
Fascia diaphragmatis pelvis inferior	Anal fascia
M. bulbo-cavernosus	Ejaculator urinae

THE NERVOUS SYSTEM.

Spinal Cord.

Fasciculus anterior proprius (Flechsig)	Anterior ground or basis bundle
Fasciculus lateralis proprius	Lateral ground bundle
Nucleus dorsalis	Clarke's column
Pars thoracalis	Dorsal part of spinal cord
Sulcus intermedius posterior	Paramedian furrow
Columnæ anteriores, etc.	Anterior grey column
Fasciculus cerebro-spinalis anterior	Direct pyramidal tract
Fasciculus cerebro-spinalis lateralis (pyramidalis)	Crossed pyramidal tract
Fasciculus cerebello-spinalis	Direct cerebellar tract
Fasciculus antero-lateralis superficialis	Gowers' tract

Brain.

Rhombencephalon	
Eminentia medialis	Eminentia teres
Ala cinerea	Trigonum vagi
Ala acustica	Trigonum acusticum
Nucleus nervi abducentis	Nucleus of 6th nerve
Nuclei n. acustici	Auditory nucleus

The Brain or Encephalon is divided into parts as follows :—

- **RHOMBENCEPHALON** = Myelencephalon (medulla) (after-brain) / Metencephalon (pons and cerebellum) (hind-brain) } Posterior primary vesicle.
- **CEREBRUM** = **MESENCEPHALON** (mid-brain, peduncles, corpora quadrigemina, etc.)—Middle primary vesicle.
  - **PROSENCEPHALON** (fore-brain)
    - **Diencephalon** = Thalamencephalon (inter-brain)
      - Thalamus (optic thalamus).
      - Metathalamus (geniculate bodies).
      - Epithalamus (pineal body).
    - Mammillary portion of hypothalamus (subthalamic region).
    - Posterior part of 3rd ventricle.
    - **Telencephalon**
      - Optic portion of hypothalamus (hypophysis).
      - Optic nerves.
      - Anterior part of 3rd ventricle.
      - Pallium (cortex cerebri).
      - Lateral ventricles.

B.N.A. TERMINOLOGY.	OLD TERMINOLOGY.
Fasciculus longitudinalis medialis	Posterior longitudinal bundle
Corpus trapezoideum	Corpus trapezoides
Incisura cerebelli anterior	Semilunar notch (of cerebellum)
Incisura cerebelli posterior	Marsupial notch
Sulcus horizontalis cerebelli	Great horizontal fissure
Lobulus centralis	Lobus centralis
Folium vermis	Folium cacuminis
Tuber vermis	Tuber valvulæ
Lobulus quadrangularis	Quadrate lobule
Brachium conjunctivum cerebelli	Superior cerebellar peduncle
Lobulus semilunaris superior	Postero-superior lobule
Lobulus semilunaris inferior	Postero-inferior lobule
Cerebrum	
Pedunculus cerebri	Crus cerebri
Colliculus superior	Anterior corpus quadrigeminum
Colliculus inferior	Posterior corpus quadrigeminum
Aqueductus cerebri	Iter e tertio ad quartum ventriculum, or aqued. of Sylvius
Foramen interventriculare	Foramen of Monro
Hypothalamus	Subthalamic region
Sulcus hypothalamicus	Sulcus of Monro
Massa intermedia	Middle commissure
Fasciculus thalamo-mammillaris	Bundle of Vicq d'Azyr
Pars opercularis	Pars basilaris
Thalamus	Optic thalamus
Pallium	Cortex cerebri
Gyri transitivi	Annectant gyri
Fissura cerebri lateralis	Fissure of Sylvius
Gyrus temporalis superior	First temporal gyrus
Gyrus temporalis medius	Second temporal gyrus
Gyrus temporalis inferior	Third temporal gyrus
Sulcus centralis (Rolandi)	Fissure of Rolando
Sulcus temporalis superior	Parallel sulcus
Sulcus temporalis medius	Second temporal sulcus
Sulcus circularis	Limiting sulcus of Reil
Sulcus temporalis inferior	Occipito-temporal sulcus
Gyrus fusiformis	Occipito-temporal convolution
Sulcus interparietalis	Intraparietal sulcus
Sulcus corporis callosi	Callosal sulcus
Sulcus cinguli	Calloso-marginal fissure
Fissura hippocampi	Dentate fissure
Gyrus cinguli	Callosal convolution
Stria terminalis	Tænia semicircularis
Trigonum collaterale	Trigonum ventriculi
Hippocampus	Hippocampus major
Digitationes hippocampi	Pes hippocampi
Fascia dentata hippocampi	Gyrus dentatus
Columna fornicis	Anterior pillar of fornix
Septum pellucidum	Septum lucidum
Inferior cornu	Descending horn of lateral ventricle
Commissura hippocampi	Lyra
Nucleus lentiformis	Lenticular nucleus
Pars frontalis capsulæ internæ	Anterior limb (of internal capsule)
Pars occipitalis capsulæ internæ	Posterior limb (of internal capsule)
Radiatio occipito-thalamica	Optic radiation
Radiatio corporis callosi	Radiation of corpus callosum
Pars frontalis	Forceps minor
Pars occipitalis	Forceps major

Membranes of Brain.

B.N.A. Terminology.	Old Terminology.
Cisterna cerebello-medullaris	Cisterna magna
Cisterna interpeduncularis	Cisterna basalis
Granulationes arachnoideales	Pacchionian bodies
Tela chorioidea ventriculi tertii	Velum interpositum
Tela chorioidea ventriculi quarti	Tela choroidea inferior

Cerebral Nerves.

N. oculomotorius	Third nerve
N. trochlearis	Fourth nerve
N. trigeminus	Fifth nerve
Ganglion semilunare (Gasseri)	Gasserian ganglion
N. naso-ciliaris	Nasal nerve
N. maxillaris	Superior maxillary nerve
N. meningeus (medius)	Recurrent meningeal nerve
N. zygomaticus	Temporo-malar nerve
Rami alveolares superiores posteriores	Posterior superior dental
Rami alveolares superiores medii	Middle superior dental
Rami alveolares superiores anteriores	Anterior superior dental
Ganglion spheno-palatinum	Meckel's ganglion
N. palatinus medius	External palatine nerve
N. mandibularis	Inferior maxillary nerve
Nervus spinosis	Recurrent nerve
N. alveolaris inferior	Inferior dental
N. abducens	Sixth nerve
N. facialis	Seventh nerve
N. intermedius	Pars intermedia of Wrisberg
N. acusticus	Eighth or auditory nerve
Ganglion superius	Jugular ganglion of 9th nerve
N. recurrens	Recurrent laryngeal nerve
Ganglion jugulare	Ganglion of root of vagus
Ganglion nodosum	Ganglion of trunk of vagus
Plexus œsophageus anterior Plexus œsophageus posterior	Plexus gulæ
Nervus accessorius	Spinal accessory
Ramus internus	Accessory portion of spinal accessory nerve
Ramus externus	Spinal portion

Spinal Nerves.

Rami posteriores	Posterior primary divisions
Rami anteriores	Anterior primary divisions
N. cutaneus colli	Superficial cervical nerve
Nn. supraclaviculares anteriores	Suprasternal nerves
Nn. supraclaviculares medii	Supraclavicular nerves
Nn. supraclaviculares posteriores	Supra-acromial nerves
N. dorsalis scapulæ	Nerve to the rhomboids
Nn. intercosto-brachiales	Intercosto-humeral nerve

B.N.A. Terminology.	Old Terminology.
N. thoracalis longus	Nerve of Bell
N. thoraco-dorsalis	Long subscapular nerve
N. cutaneus brachii medialis	Lesser internal cutaneous nerve
N. cutaneus brachii lateralis	Cutaneous branch of circumflex nerve
Fasciculus lateralis	Outer cord (of plexus)
Fasciculus medialis	Inner cord
N. cutaneus antibrachii lateralis	Cutaneous branch of musculo-cutaneous nerve
N. cutaneus antibrachii medialis	Internal cutaneous nerve
Ramus volaris	Anterior branch
Ramus ulnaris	Posterior branch
N. cutaneus antibrachii dorsalis	External cutaneous branch of musculo-spiral
N. axillaris	Circumflex nerve
N. interosseus volaris	Anterior interosseous nerve
Ramus palmaris N. mediani	Palmar cutaneous branch of the median nerve
Nn. digitales volares proprii	Collateral palmar digital branches of median nerve
Ramus dorsalis manus	Dorsal cutaneous branch of ulnar nerve
Ramus cutaneus palmaris	Palmar cutaneous branch of ulnar nerve
N. radialis	Musculo-spiral nerve
N. cutaneus brachii posterior	Internal cutaneous branch of musculo-spiral nerve
N. cutaneus antibrachii dorsalis	External cutaneous branches of musculo-spiral nerve
Ramus superficialis	Radial nerve
N. interosseus dorsalis	Posterior interosseous nerve
Nn. digitales dorsales	Dorsal digital nerves
N. ilio-hypogastricus	Ilio-hypogastric nerve
Ramus cutaneus lateralis	Iliac branch of ilio-hypogastric nerve
Ramus cutaneus anterior	Hypogastric branch of ilio-hypogastric nerve
N. genito-femoralis	Genito-crural nerve
N. lumbo-inguinalis	Crural branch of genito-crural nerve
N. spermaticus externus	Genital branch of genito-crural nerve
N. cutaneus femoris lateralis	External cutaneous nerve
N. femoralis	Anterior crural nerve
N. saphenus	Long saphenous nerve
Ramus infrapatellaris	Patellar branch of long saphenous nerve
N. ischiadicus	Great sciatic nerve
N. peronæus communis	External popliteal nerve
Ramus anastomoticus peronæus	Nervus communicans fibularis
N. peronæus superficialis	Musculo-cutaneous nerve
N. peronæus profundus	Anterior tibial nerve
N. tibialis	Internal popliteal nerve
N. cutaneus suræ medialis	Nervus communicans tibialis
N. suralis	Short saphenous nerve
N. plantaris medialis	Internal plantar nerve
N. plantaris lateralis	External plantar nerve
N. pudendus	Pudic nerve

THE HEART AND BLOOD-VESSELS.

Heart.

B.N.A. Terminology.	Old Terminology.
Atrium	Auricle
Auricula cordis	Auricular appendix
Incisura cordis	Notch at apex of heart
Trabeculæ carneæ	Columnæ carneæ
Tuberculum intervenosum	Intervenous tubercle of Lower
Sulcus longitudinalis anterior	Anterior interventricular groove
Sulcus coronarius	Auriculo-ventricular groove
Limbus fossæ ovalis	Annulus ovalis
Valvula venæ cavæ	Eustachian valve
Valvula sinus coronarii	Valve of Thebesius

Arteries.

Sinus aortæ	Sinuses of Valsalva
A. profunda linguæ	Ranine artery
A. maxillaris externa	Facial artery
A. alveolaris inferior	Inferior dental artery
Ramus meningeus accessorius	Small meningeal artery
A. buccinatoria	Buccal artery
A. alveolaris superior posterior	Posterior dental artery
Aa. alveolares superiores anteriores	Anterior superior dental arteries
Ramus carotico-tympanicus	Tympanic branch of int. carotid
A. chorioidea	Anterior choroidal artery
A. auditiva interna	Auditory artery
Rami ad pontem	Transverse arteries (branches of Basilar artery)
A. pericardiaco-phrenica	Arteria comes nervi phrenici
Rami intercostales	Anterior intercostal arteries
Truncus thyreo-cervicalis	Thyroid axis
A. transversa scapulæ	Suprascapular artery
A. intercostalis suprema	Superior intercostal
A. transversa colli	Transversalis colli
A. thoracalis suprema	Superior thoracic artery
A. thoraco-acromialis	Acromio-thoracic artery
A. thoracalis lateralis	Long thoracic artery
A. circumflexa scapulæ	Dorsalis scapulæ
A. profunda brachii	Superior profunda
A. collateralis radialis	Anterior branch of superior profunda
A. collateralis ulnaris superior	Inferior profunda
A. collateralis ulnaris inferior	Anastomotica magna
Ramus carpeus volaris	Anterior radial carpal
Ramus carpeus dorsalis	Posterior radial carpal
Aa. metacarpeæ dorsales	Dorsal interosseous arteries
A. volaris indicis radialis	Radialis indicis
Arcus volaris superficialis	Superficial palmar arch
Arcus volaris profundus	Deep palmar arch
A. interossea dorsalis	Posterior interosseous artery
A. interossea recurrens	Posterior interosseous recurrent artery
A. interossea volaris	Anterior interosseous artery
Ramus carpeus dorsalis	Posterior ulnar carpal
Ramus carpeus volaris	Anterior ulnar carpal
Aa. digitales volares communes	Palmar digital arteries
Aa. digitales volares propriæ	Collateral digital arteries

B.N.A. Terminology.	Old Terminology.
Right gastric	Pyloric
Left gastric	Coronary
Arteriæ intestinales	Intestinal branches of sup. mesenteric
A. suprarenalis media	Middle capsular artery
A. hypogastrica	Internal iliac artery
A. umbilicalis	Obliterated hypogastric
A. pudenda interna	Internal pudic artery
A. epigastrica inferior	Deep epigastric artery
A. spermatica externa	Cremasteric artery
Aa. pudendæ externæ	Superficial and deep external pudic arteries
A. circumflexa femoris medialis	Internal circumflex artery
A. circumflexa femoris lateralis	External circumflex artery
A. genu suprema	Anastomotica magna
A. genu superior lateralis	Superior external articular artery
A. genu superior medialis	Superior internal articular artery
A. genu media	Azygos articular artery
A. genu inferior lateralis	Inferior external articular artery
A. genu inferior medialis	Inferior internal articular artery
A. malleolaris anterior lateralis	External malleolar artery
A. malleolaris anterior medialis	Internal malleolar artery
A. peronæa	Peroneal artery
Ramus perforans	Anterior peroneal artery
A. malleolaris posterior lateralis	Posterior peroneal artery
A. malleolaris posterior medialis	Internal malleolar artery
Rami calcanei laterales	External calcanean artery
Rami calcanei mediales	Internal calcanean artery
A. plantaris medialis	Internal plantar artery
A. plantaris lateralis	External plantar artery
Aa. metatarseæ plantares	Digital branches
Aa. digitales plantares	Collateral digital branches

Veins.

B.N.A. Terminology.	Old Terminology.
V. cordis magna	Great cardiac vein
V. obliqua atrii sinistri	Oblique vein of Marshall
Lig. venæ cavæ sinistræ	Vestigial fold of Marshall
Vv. cordis minimæ	Veins of Thebesius
Sinus transversus	Lateral sinus
Confluens sinuum	Torcular Herophili
Plexus basilaris	Basilar sinus
Sinus sagittalis superior	Superior longitudinal sinus
Sinus sagittalis inferior	Inferior longitudinal sinus
Spheno-parietal sinus	Sinus alæ parvæ
V. cerebri internæ	Veins of Galen
V. cerebri magna	Vena magna Galeni
V. terminalis	Vein of the corpus striatum
V. basalis	Basilar vein
V. transversa scapulæ	Suprascapular vein
V. thoraco-acromialis	Acromio-thoracic vein
Vv. transversæ colli	Transversalis colli veins
V. thoracalis lateralis	Long thoracic vein
V. azygos	Vena azygos major
V. hemiazygos	Vena azygos minor inferior
V. hemiazygos accessoria	Vena azygos minor superior
V. hypogastrica	Internal iliac vein
V. epigastrica inferior	Deep epigastric vein
V. saphena magna	Internal saphenous vein
V. saphena parva	External saphenous vein

Lymphatics.

B.N.A. TERMINOLOGY.	OLD TERMINOLOGY.
Cisterna chyli	Receptaculum chyli

THE VISCERA.

Digestive Apparatus.

Arcus glosso-palatinus	Anterior pillar of fauces
Arcus pharyngo-palatinus	Posterior pillar of fauces
Gl. lingualis anterior	Gland of Nuhn
Ductus submaxillaris	Wharton's duct
Gl. parotis accessoria	Socia parotidis
Ductus parotideus (Stenonis)	Stenson's duct
Dentes præmolares	Bicuspid teeth
Dens serotinus	Wisdom tooth
Papillæ vallatæ	Circumvallate papillæ
Recessus pharyngeus	Lateral recess of pharynx
Tela submucosa	Pharyngeal aponeurosis
Plicæ circulares	Valvulæ conniventes
Gl. intestinales	Crypts of Lieberkühn
Valvula coli	Ileo-cæcal valve
Columnæ rectales	Columns of Morgagni
Plicæ transversales recti	Valves of Houston
Valvula spiralis	Valves of Heister
Noduli lymphatici aggregati (Peyeri)	Peyer's patches
Intestinum jejunum	Jejunum
Intestinum ileum	Ileum
Noduli lymphatici lienales (Malpighii)	Malpighian corpuscles

Respiratory Apparatus.

Larynx	
Prominentia laryngea	Adam's apple
Incisura thyreoidea superior	Superior thyroid notch
M. ary-epiglotticus	Aryteno-epiglottidean muscle
M. vocalis	Internal thyro-arytenoid muscle
M. thyreo-epiglotticus	Thyro-epiglottidean muscle
Appendix ventriculi laryngis	Laryngeal sac
Plica vocalis	True vocal cord
Plica ventricularis	False vocal cord
Ligamentum ventriculare	Superior thyro-arytenoid ligament
Ligamentum vocale	Inferior thyro-arytenoid ligament
Glottis	Glottis vera
Rima vestibuli	Glottis spuria
Cartilago thyreoidea	Thyroid cartilage
Membrana hyo-thyreoidea	Thyro-hyoid membrane
Cartilago corniculata (Santorini)	Cartilage of Santorini
Tuberculum epiglotticum	Cushion of epiglottis
Pars intermembranacea (rimæ glottidis)	Glottis vocalis
Pars intercartilaginea (rimæ glottidis)	Glottis respiratoria

B.N.A. TERMINOLOGY.	OLD TERMINOLOGY.
Conus elasticus (membraneæ elasticæ laryngis)	Crico-thyroid membrane
Glandula thyreoidea	Thyroid gland
Glomus caroticum	Intercarotid gland or body

Nose

Concha nasalis suprema (Santorini)	Highest turbinate bone
Concha nasalis superior	Superior turbinate bone
Concha nasalis media	Middle turbinate bone
Concha nasalis inferior	Inferior turbinate bone

Urogenital Apparatus.

Corpuscula renis	Malpighian corpuscles
Paradidymis	Organ of Giraldés
Appendix testis	Hydatid of Morgagni (male)
Ductus deferens	Vas deferens
Gl. urethrales	Glands of Littré
Glandula bulbo-urethralis (Cowperi)	Cowper's gland
Folliculi oophori vesiculosi	Graafian follicles
Cumulus oophorus	Discus proligerus
Tuba uterina	Fallopian tube
Epoophoron	Parovarium
Appendices vesiculosi	Hydatids of Morgagni (female)
Ductus epoophori longitudinalis	Gärtner's duct
Orificium internum uteri	Internal os (of uterus)
Orificium externum	External os
Processus vaginalis	Canal of Nuck
Glandula magna vestibuli	Bartholin's gland

Peritoneum.

Bursa omentalis	Lesser peritoneal sac
Foramen epiploicum	Foramen of Winslow
Lig. phrenico-colicum	Costo-colic ligament
Excavatio recto-uterina (cavum Douglasi)	Pouch of Douglas
Lig. gastro-lienale	Gastro-splenic omentum

SENSE ORGANS.

The Eye.

Sclera	Sclerotic coat
Lamina elastica anterior (Bowmani)	Bowman's membrane
Lamina elastica posterior (Descemeti)	Descemet's membrane
Spatia anguli iridis	Spaces of Fontana
Angulus iridis	Irido-corneal junction
Zonula ciliaris	Zonule of Zinn
Septum orbitale	Palpebral ligament
Fascia bulbi	Capsule of Tenon
Commissura palpebrarum lateralis	External canthus

B.N.A. Terminology.	Old Terminology.
Commissura palpebrarum medialis	Internal canthus
Tarsus superior	Superior tarsal plate
Tarsus inferior	Inferior tarsal plate
Lig. palpebrale mediale	Internal tarsal ligament
Raphe palpebralis lateralis	External tarsal ligament
Tarsal glands	Meibomian glands

The Ear.

Canalis semicircularis lateralis	External semicircular canal
Ductus reuniens	Canalis reuniens
Ductus cochlearis	Membranous cochlea
Recessus sphericus	Fovea hemispherica
Recessus ellipticus	Fovea hemi-elliptica
Paries jugularis	Floor of tympanum
Paries labyrinthica	Inner wall
Fenestra vestibuli	Fenestra ovalis
Fenestra cochlæ	Fenestra rotunda
Paries mastoidea	Posterior wall
Antrum tympanicum	Mastoid antrum
Paries carotica	Anterior wall
Processus lateralis	Processus brevis (of malleus)
Processus anterior	Processus gracilis

MANUAL OF OPERATIVE SURGERY

CHAPTER I

INTRODUCTORY

THE present Manual of Operative Surgery has for its object the consideration and description of the various surgical operations which may be performed on the human organism, for the alleviation or radical cure of those malformations, diseases, or injuries amenable to direct surgical interference.

It is necessary, however, in order to ensure as far as possible a satisfactory and successful result to all justifiable and advisable surgical operations, that the operator should be thoroughly familiar and acquainted with all the minute details of the modern technique of "prevention of wound infection."

Causes of wound infection.—Bacteriology has conclusively shown that all inflammatory processes in connection with complications of recent wounds are caused by the presence of pathogenic micro-organisms, together with the products of their vital activity in the actual wounds themselves. The pathogenic micro-organisms which give rise to the development of the above-mentioned complications are not confined to one variety. Most cases of wound inflammation or suppuration are due to an infection with one or other, or sometimes more than one, member of the group of pyogenic bacteria. Of this group, *Staphylococcus pyogenes aureus* and *albus*, and some varieties of *Streptococcus*, are most commonly found; while *Bacillus coli communis*, *B. pyogenes fœtidus* and *B. pyocyaneus*, and *Staphylococcus pyogenes citreus* are occasionally met with. Examples of pathogenic micro-organisms, which give rise to special forms of wound infection, are *Bacillus tetani*—the cause of tetanus; *B. anthracis*—the cause of malignant pustule; *B. tuberculosis*

—the cause of tuberculosis; and *B. diphtheriæ*—the cause of diphtheria. For a detailed discussion of the different varieties of pathogenic micro-organisms, and the biological, physical, and chemical conditions which favour or retard their growth and multiplication, the student is referred to works upon Surgical Pathology, Bacteriology, and the Principles of Surgery.

The actual causes of inflammation and suppuration in a wound appear to be the toxins or certain other ferment-like bodies which are produced by the growth and metabolism of the different varieties of pathogenic micro-organisms.

When it is admitted that "wound infection" is always the result of the presence of micro-organisms, and when it is known that these micro-organisms live and thrive in certain situations and under certain more or less well understood conditions in the animal body or outside, or, on the other hand, die or lose their virulence under certain other conditions, then it is self-evident that a successful surgeon must be thoroughly acquainted with all the various factors which favour the presence and growth of bacteria. By the application of this knowledge he may avoid infection of wounds by them, or employ such preventive measures as will hinder their growth or destroy them.

Sources of wound infection.—Every substance, material, or part of the operator and his assistants, brought in contact with or in close approximation to a recent wound, may be a carrier of pathogenic micro-organisms and the direct cause of "wound infection" and its complications, if they have not previously been rendered surgically clean by a process of sterilisation.

The fertile sources of "wound infection" are, most commonly, insufficient preparation of the skin of the patient within the field of operation; incomplete cleansing and sterilisation of the hands and arms of the operator, assistant, or nurses; inefficient sterilisation of instruments, operation clothing and gloves, suture and ligature material, drainage tubes, sponges, swabs, towels, or dressings, or contamination of one of these agents, during the performance of the actual operation, by contact with a body or substance which has not previously been made quite sterile.

Bacteriologists have shown that the cavity of the mouth invariably contains numbers of pathogenic bacteria, and recent investigations have conclusively demonstrated that much talking in a room increases very considerably the numbers of micro-organisms floating about in the air of the room. From this it is clear that talking during the performance of an operation is to be deprecated, owing to the increased contamination of the atmosphere of the operation room, and also the risk of small particles of saliva, containing pathogenic micro-organisms, falling directly into an open wound.

In the performance of operations in private houses, it is a very essential factor, as regards the success of the procedure, that the room in which the operation is to be performed should be specially prepared and made as clean as possible, or as the circumstances of the individual case will allow.

A good well-equipped and well-planned operation room, fitted with the modern elaborate appliances for ensuring asepsis, is very desirable in the performance of all surgical operations; but in emergency work, work in country districts, or under conditions where a proper operation theatre or room is not immediately available, this is not possible, and the surgeon is obliged to carry out his proceedings with such space, accommodation, and appliances as may be at hand. On this account it is very important that the student should be familiar with the best methods for arranging and preparing a room in a private house, so as to transform it into a comparatively satisfactory operating room. It may be urged that this is the work of a trained nurse, and that a surgeon ought not to be expected to superintend or initiate the carrying out of details of this kind. This, however, is unjustifiable; and it cannot be too strongly impressed on the would-be successful surgeon, that every detail of the preparation of the operation room, the instruments, dressings, ligatures, swabs, sponges, etc., and of the preparation of each individual patient, must be supervised, overlooked, and directed by himself.

In the case of incompetent, untrained, or careless assistants and nurses, he must personally superintend or give explicit directions as to the method of carrying out correctly and completely all the technical details.

Complete and efficient disinfection of the hands and forearms of operator and assistants, instruments, sponges, swabs, rubber gloves, operation gowns, masks, dressings, and the skin of the patient within the field of operation, is the most essential factor in the successful treatment of recent wounds, and hence in the practice of operative surgery.

These important preliminary and general considerations will now be discussed in detail.

CHAPTER II

GENERAL SURGICAL TECHNIQUE

Selection of instruments.—Before a surgical operation is commenced, all instruments which may be required during its performance should be selected and rendered sterile. In order to make a selection satisfactorily, it is necessary to review mentally the different stages of the operation, and to decide what instruments are requisite for each stage. Thus, whenever an incision through the skin has to be made, a cutting instrument, such as a scalpel, is requisite ; if the proposed wound is to be a deep one, or the anatomical structure upon which it is proposed to operate is not readily exposed, retractors are required ; if blood vessels are to be divided, pressure forceps are necessary ; and if a bone requires section, a saw of appropriate size and shape, or bone forceps, must be taken. Needles and a needle-holder are also essential when a wound or part of a wound has to be closed, and in all cases ligature and suture material of proper thickness must be in readiness.

Modern surgery and the practice of aseptic and antiseptic principles has effected a considerable modification in the manufacture of surgical instruments. Every instrument or appliance should be manufactured in such a manner that there are as few crevices and irregularities as possible, whilst in the case of scissors and forceps they should be so made that the two blades can be readily separated, one from the other, in order to facilitate cleaning. Ornamentation of the handles or other parts of instruments, by engraving or otherwise, should not be allowed ; and it should be insisted upon, that all instruments should be as plain and smooth as is consistent with the uses to which they are to be put. Knives, saws, etc., must have metal handles, all instruments with bone, wood, or ivory handles being discarded. It is a great advantage that each instrument should be as light and small as possible, since this renders efficient and ready sterilisation a far simpler matter than is the case with the heavy and often cumbrous instruments which were so commonly used by the previous generation of surgeons. This remark applies especially to the very long sword-like amputating knives which were always used when the transfixion methods of amputation were in vogue. Now, in the majority of instances, an amputation is carried out with a moderate-sized scalpel or short resection knife with a strong, firm handle. It is not advisable to use knives which are so made that several blades can be fitted to one handle, or are of the so-called " many-bladed " variety.

As a general rule, it may be stated that only a few instruments are required for the performance of any individual operation, assuming that these are selected with care and the operator is quite familiar with their use. For the convenience of students, I append the following short list of instruments, which comprises what are essential for the majority of surgical operations. When an operation is being described in the later parts of the book, in which any special instrument or form of surgical appliance is necessary, it will be mentioned under the heading of " Special Instruments " ; in other cases, the instruments necessary will be those given below :—

(*a*) Knife or scalpel of suitable size and shape.
(*b*) Retractors of suitable size and shape.
(*c*) Two pairs of dissecting forceps.
(*d*) Scissors of suitable size and shape (two pairs may be necessary, straight and curved).
(*e*) Hæmostatic forceps (of suitable size and shape).
(*f*) Blunt-pointed curved needle on a handle.
(*g*) A probe-pointed director.
(*h*) Needles of proper size and shape.
(*i*) Needle-holder.
(*k*) Ligature and suture material.
(*l*) Towel clips.

The student of surgery, from the commencement of his career, ought to accustom himself to use as few instruments as possible during the performance of an operation, and also should make himself thoroughly familiar with the uses to which any ordinary instrument can be put.

Sterilisation of instruments.—During the evolution of surgery many different methods have been practised for the disinfection of surgical instruments. Some of these were dependent upon the employment of chemical agents, others upon the use of some form of heat. Now, it is almost universally admitted that the only satisfactory method of sterilisation of instruments which can be readily employed, is by " boiling in water which contains 1 per cent. of carbonate of soda." The addition of carbonate of soda is necessary, since boiling steel instruments in water rusts them and thus renders them comparatively useless, especially those which have a sharp or cutting edge. This blunting of sharp and cutting edges is almost entirely obviated by adding to each litre of water a tablespoonful of crystallised carbonate of soda. (Tablets of carbonate of soda can be obtained, two of which added to a pint of water make a 1 per cent. solution.) Ordinary washing soda serves the purpose perfectly well. Experiments have shown that the addition of carbonate of soda intensifies the sterilising action of boiling water. A 1 per cent. solution appears to be the most effective. It will thus be seen that the agents for efficiently sterilising surgical instruments are always at hand. All that is necessary is water, fire, carbonate of soda (common washing soda), and a metallic vessel of sufficient size to hold the instruments. When sterilising cutting instruments, it is an advantage to place the instruments in the solution only after it has been raised to the boiling point; immersion in a boiling 1 per cent. solution of carbonate of soda in water, for from five to ten minutes, efficiently and completely sterilises all

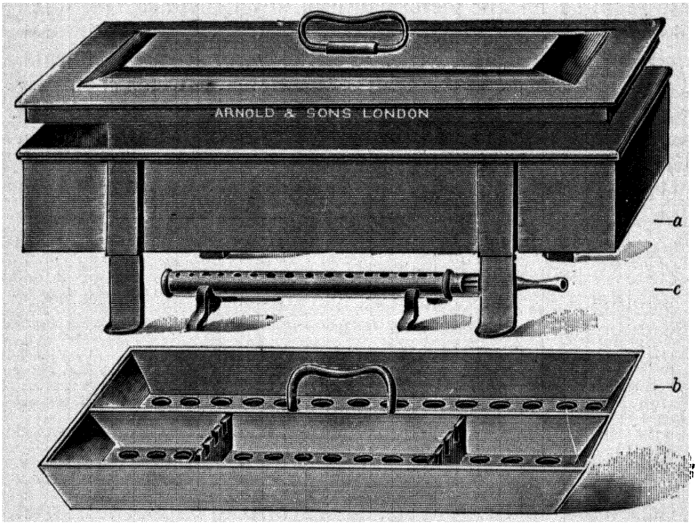

FIG. 1.—Steriliser for instruments, ligatures, etc.

a. Steriliser.
b. Removable tray.
c. Gas burner. (This can be replaced by a spirit lamp.)

ordinary surgical instruments and appliances. Large and heavy instruments, however, such as bone forceps, metal mallets and chisels and osteotomes, require a longer time to ensure sterilisation.

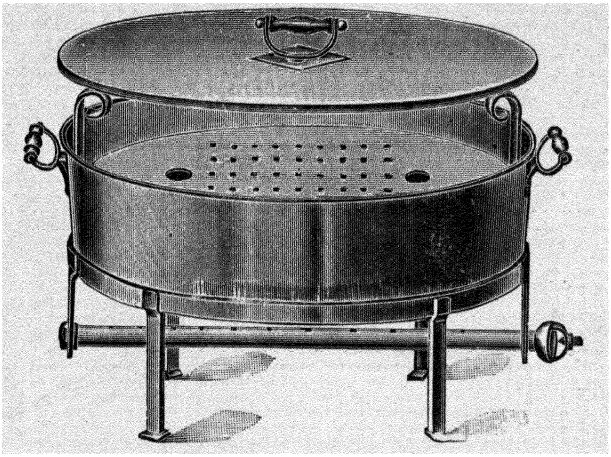

FIG. 2.—Large steriliser for instruments.

An instrument, the **steriliser,** of the form and shape shown in Fig. 1, is a very useful one for ordinary surgical practice. It consists of an oblong metallic vessel with a closely fitting lid,

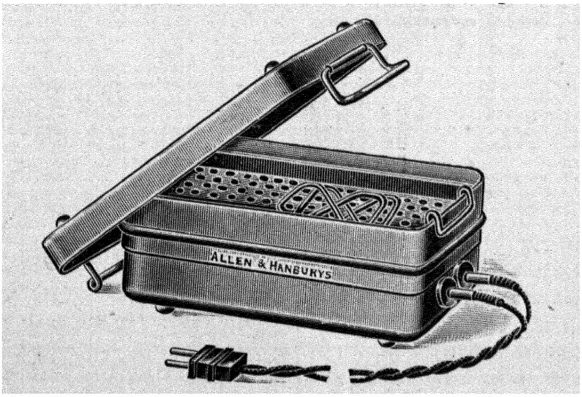

FIG. 3.—Instrument steriliser, heated by electricity.

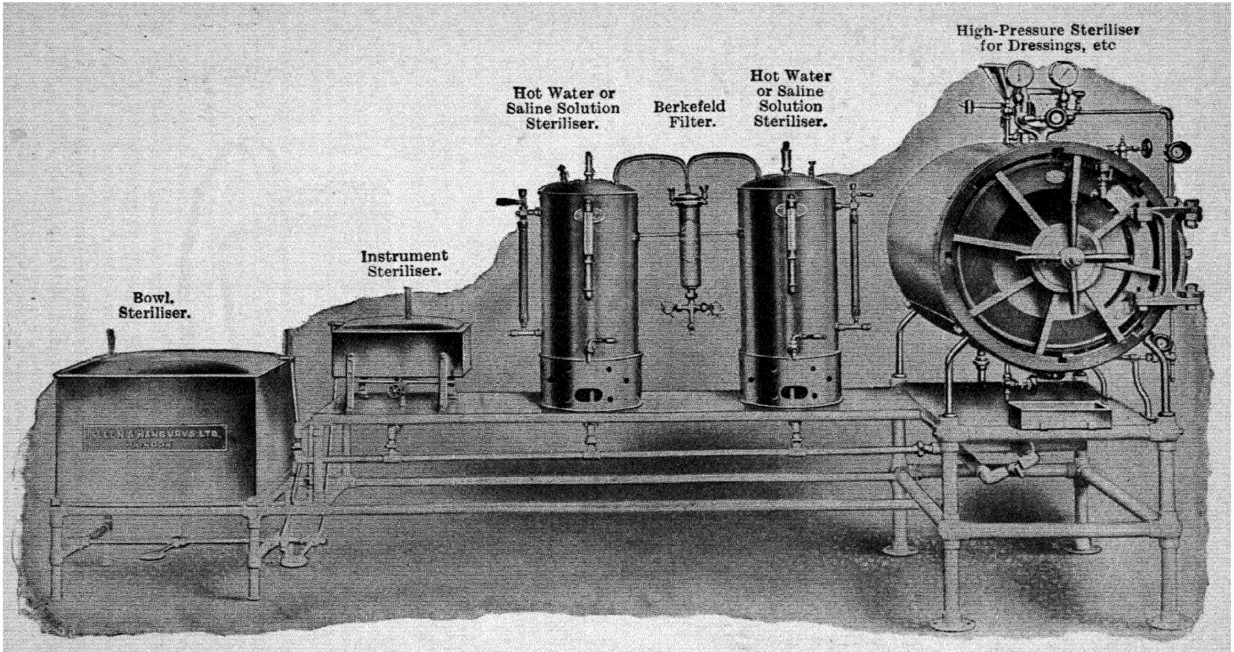

FIG. 4.—Set of sterilisers; for use in connection with operation rooms. The best form of heating is superheated steam, but electricity, coal gas, or methylated spirit can be used.

supported on four detachable supports. The interior is fitted with a metallic tray, which has a handle for lifting, a rack for holding scalpels, needles mounted on handles, etc., and a compartment for ligature reels. It can be heated either by a gas burner or spirit lamp. The advantage of having the supports detachable is that they can be taken off and the entire steriliser readily packed away in a moderate-sized operation bag. An ordinary domestic " fish kettle " of enamelled iron makes a good steriliser in case of emergency. Whenever a specially fitted operation theatre is available, an enlarged form of steriliser is convenient. Fig. 2 illustrates a much-used form.

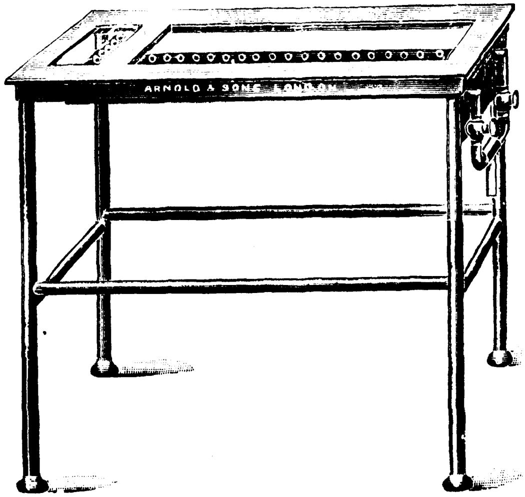

Fig. 5.—Table for sterilisers heated by gas. The large gas burner is for the steriliser for instruments, and the small one that for ligatures and sutures.

For hospital purposes and wherever many surgical procedures are being carried out, a very useful form of table for sterilisers is shown in Fig. 5. The larger steriliser is for instruments, and the small one for ligatures. A steriliser of this kind may be heated by a spirit lamp, gas burner, electricity, or superheated steam.

A combination set of sterilisers is shown in Fig. 4, which is the most useful form for operation rooms, and ought to be placed in a room directly adjacent to and communicating with an operation theatre.

Rubber and glass drainage tubes, glass syringes, and similar surgical appliances are disinfected and made sterile by boiling in a solution of carbonate of soda, such as has been described. Special care is required in the sterilisation of rubber-tubing. Long or thick pieces require much longer boiling to ensure efficient sterilisation.

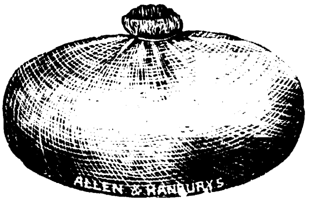

FIG. 6.—Mop or swab of cotton wool covered with a layer of gauze.

Selection and sterilisation of sponges, "swabs," or "tampons" of cotton wool, gauze, lint, Iceland moss, etc.—Many substances are used for removing blood, débris, exudations, and lotions from operation wounds. The most important of these are gauze, cotton wool, wood wool, and ordinary lint. All these can be readily sterilised in the high-pressure steam steriliser, which is described in connection with the disinfection and sterilisation of dressings, towels, operation gowns, etc. When they have been soiled during an operation they are thrown away. Each "swab," tampon, or compress of cotton wool or wood wool should be enclosed in a piece of gauze. This prevents adhesion of loose particles to the tissues. When abscesses or other suppurative affections are being treated, "sponges" made of cotton wool are the best, as they are cheap, efficient, and can be at once thrown away. In aseptic operations, also, sponges of cotton wool enclosed in gauze, or of folded layers of gauze, prepared by the method of sterilisation described below, will be found to be the most satisfactory. In operations upon the contents of the abdomen some surgeons prefer marine sponges; it is then necessary to have four round sponges and two flat ones at hand. In my opinion, however,

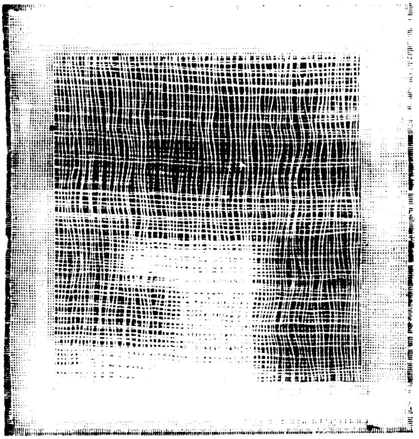

FIG. 7.—Flat gauze sponge.

flat gauze pads, or pads consisting of a thin layer of absorbent cotton wool covered externally by one or two layers of gauze, are far preferable. Very useful cotton gauze pads are those illustrated in Fig. 7 the material being woven in a cellular manner. These " pads " are especially useful in packing away coils of intestine, which impede the operator and obscure the field of the operation. When the large pads are used for abdominal operations it will be found advantageous to have several of the large ones with a tape attached to one corner. This tape can be left hanging out from a portion of the wound. This precaution facilitates removal, and helps in preventing a swab or pad being left behind.

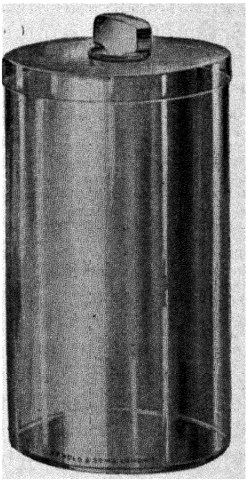
FIG. 8.—Glass jar for marine sponges. Cover is ground to fit outside.

Sterilisation of marine sponges.—Marine sponges are in some respects suitable substances for removing blood, débris, lotion, etc., from a wound during the performance of a surgical operation. An objection to their use is the difficulty which is experienced in making them sterile. Boiling in water or a solution of carbonate of soda destroys their texture and makes them friable. On this account other measures have to be adopted to prepare them for use. Fresh sponges of suitable size and shape and of a fine texture are selected, and thoroughly washed in a stream of water in order to remove the particles of sand which are generally found to be present in them. This substance is often added in order to increase the weight, and so enhance their *commercial* value. When they contain small particles of coral or shell they must be soaked for twenty-four hours or more in a 2 per cent. solution of hydrochloric acid. This reagent dissolves the calcareous particles, and after this has been done they are washed in a stream of water to remove all traces of acid. Next, the sponges are thoroughly washed in hot water (105° F.) and soft soap (potash soap), and then in water with a mixture of soft soap and turpentine. By these means all dirt, particles of sand, coral, or shell, and fat or grease, are removed. The sponges are now washed in warm water, to remove the soap, and then placed in a closely covered glass jar containing a strong solution of formalin. In this they are allowed to remain forty-eight to sixty hours, then they are removed and washed in water which has been sterilised by boiling. They are finally placed in a glass jar containing a solution of carbolic acid 1 in 20. The lid or cover ought to be ground so as to fit on the outer side of the jar, and the latter not closed with a stopper. Fig. 8 is an illustration of the form of jar most suitable for surgical work. No dirt can collect and fall into its interior on removal of the cover. They are kept in this until they are required for use. The sponges are then taken out of the glass jar, the carbolic solution expressed from them, and placed in the bowl which contains the antiseptic or aseptic lotion which is to be used during the operation. If the sponges are kept for any considerable period before being used (after being prepared), it is necessary to renew the solution of carbolic acid about every ten days or fortnight. This method of sterilisation may be tabulated thus—

(*a*) Wash in water to remove sand and solids.
(*b*) Soak in solution of 2 per cent. HCl, if requisite.
(*c*) Wash in water and soft soap.
(*d*) Wash in hot water and mixture of soft soap and turpentine.
(*e*) Wash again in hot water.
(*f*) Soak in formalin forty-eight hours.
(*g*) Wash in sterilised water, and place in carbolic acid, 5 per cent. solution, until wanted.

This method has been found to be quite safe and efficient. If the sponges are left too long in strong formalin they become rather hard, and develop a tendency to brittleness. Control experiments made by taking cultures from sponges so prepared have generally shown them to be sterile.

Another method of preparing marine sponges to make them aseptic, is the following: The sponges are first thoroughly beaten and washed, and, if new, soaked for twenty-four hours in a 2 per cent. solution of hydrochloric acid. They are again washed in water, then placed in a hot solution of carbonate of soda (1 in 15) for twenty-four hours, and again washed in warm sterilised water. Next, they are placed in a watery solution of sulphurous acid (1 in 3), and allowed to remain there for twenty-four hours. Finally, they are washed in warm sterilised water, to remove all traces of sulphurous acid, and placed in a glass jar containing a 5 per cent. solution of carbolic acid, in which they remain until they are required for use.

This method is used in some of the operating theatres of St. Bartholomew's Hospital, in preparing marine sponges for use in mouth and pharyngeal operations.

When marine sponges have been used, immediately after completion of the operation they should be placed in a hot solution of carbonate of soda. Then they are thoroughly washed with soft soap and water in order to remove all blood, débris, etc., and finally again prepared by one of the two methods detailed above.

Personally, I think "wool swabs" covered with gauze (Fig. 6) and flat woven gauze sponges (Fig. 7), or thin flat layers of absorbent wool covered by gauze, are the best materials for use in operations, owing to the fact that they can be readily and efficiently made aseptic by sterilisation in the steam steriliser. In operations upon the throat and nose and about the buccal cavity, and upon suppurating cavities in the interior of bones, marine sponges present some advantages over gauze-covered wool "swabs."

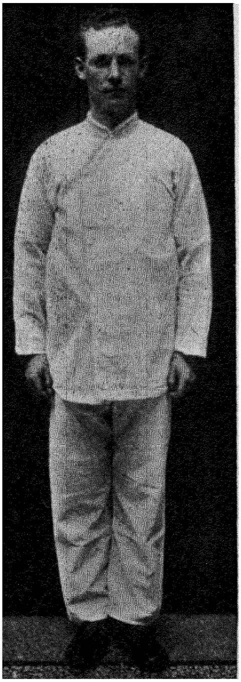
FIG. 9.—Operation suit of linen or cotton or woollen material, consisting of jacket and trousers.

Clothing of surgeon and assistant for operation.—During the performance of surgical operations, the surgeon and assistant should divest themselves of all outer articles of clothing and replace them by an operation suit of linen or cotton or woollen material (Fig. 9); or, where this is not possible, of shirt and collar, and replace them by a shirt of soft woollen material. The advantages of this are, that the surgeon has a comfortable under-garment which will absorb fluids excreted by the skin, and can be easily sterilised before use. Removal of the collar and stiff white shirt also makes movements more comfortable for the surgeon, and avoids these articles of attire being soiled with blood or contaminated with micro-organisms when dealing with septic and suppurating cases. An operation gown, of the form and shape shown in Fig. 10, which has been sterilised by moist heat in the steam steriliser, should be put on after the hands and forearms have been prepared. The gown should be made to fit the body not too tightly, so as to allow free movements, to extend downwards to the heels, to fit closely to the neck, and to fasten behind. The sleeves should extend to the wrist, and have an arrangement for being fastened.

A good practical rule which may be adopted in surgical operations is, that articles of ordinary clothing should not be allowed to extend below the elbow, and that surgeon, assistant, and nurse should each wear a sterilised gown, cap, and mask, made of some variety of woven cotton material. In emergency operations cotton sheets or large towels may be sterilised and fastened round the operator and assistant.

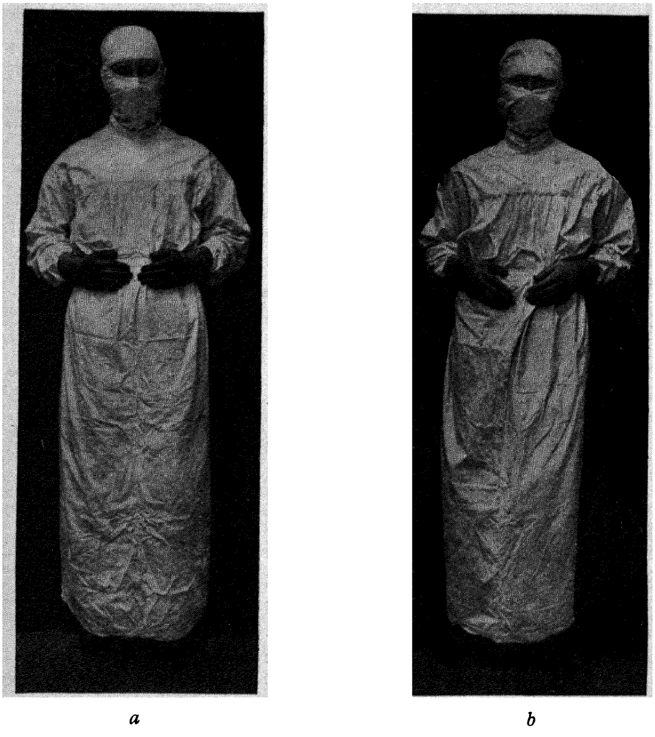

Fig. 10.—Surgeon clothed for operation.

a. View with gown, cap, mask, rubber gloves, and rubber boots.
b. View with gown, combined cap and face mask, rubber gloves, and shoes.

Caps and masks.—The surgeon, assistant, and nurse ought to wear a cap and mask of woven cotton, which can be readily sterilised by moist heat. Fig. 11 is a convenient form of cap and mask which can be obtained from ordinary trade sources. The

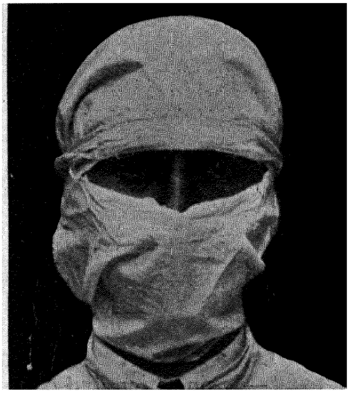

Fig. 11.—Operation cap and gauze face mask combined.

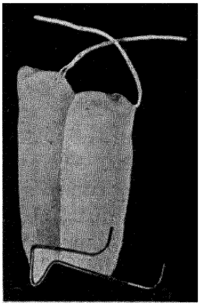

Fig. 12.—Spectacle frame for "gauze operation mask."

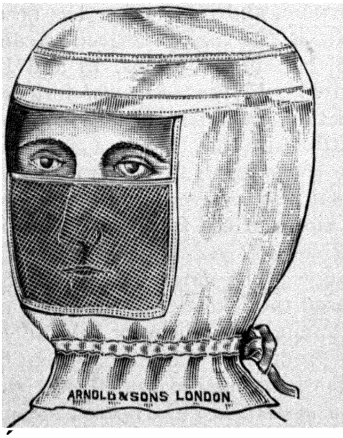

Fig. 13.—Operation mask in which a layer of cotton wool is placed between the two layers of muslin covering the nose.

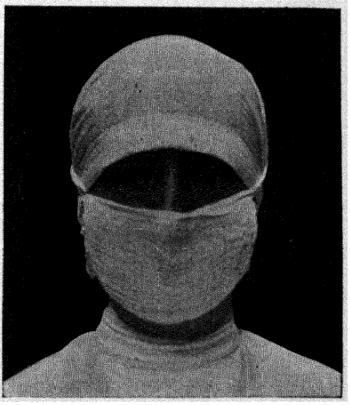

Fig. 14.—Separate cap and mask correctly put on.

use of a cap and mask helps to avoid contamination of a wound by preventing any dust, etc., attached to the hair falling into it and conveying septic micro-organisms. The cap should extend downwards so as to cover the eyebrows. Masks such as those shown in Figs. 12 and 13 are used by surgeons, but they are very hot and uncomfortable. A convenient form is the one shown in Fig. 11. When, however, a surgeon must perform an operation whilst suffering from a catarrhal condition of the nose or respiratory passages, a mask of the form depicted in Fig. 13 should be worn. The part which covers the nose consists of two layers of perforated muslin, between which a layer of cotton wool can be placed. It is better, however, for a surgeon to avoid performing operations when suffering from a catarrhal condition of the nose or naso-pharynx.

Shoes, etc.—Canvas or rubber shoes or overshoes should be worn; they can be sterilised and put on before operation. Their use avoids dust, etc., from without being introduced into the operation room.

Sterilisation of operation gowns, aprons, caps, towels, dressings, gauze, wool, and pads.—Disinfection and efficient sterilisation of operation gowns, caps, towels, cotton wool, gauze, pads, and aprons, can most readily and effectually be carried out by submitting them to the action of moist heat. The appliance which is most useful for the purpose, and by practice has been found to be thoroughly reliable, is the high-pressure "steam steriliser," depicted in Figs. 15, 16, and 17. Figs. 15 and 16 illustrate the *vertical* form, and Fig. 17 the *horizontal* form of steriliser. It consists of two metallic cylinders, usually copper, one within the other, of such relative size that there is a considerable space between them. This space forms the water chamber or boiler, and is bounded externally by a covering of metal and asbestos. A solid metal cover closes in the top or end, and is fitted tightly by rubber packing and screws. In it are placed a thermometer and a pressure gauge. The inner chamber is the sterilising one, and in it are placed the "kettles," "drums," or "boxes" (Figs. 18 and 19) containing the articles or substances it is wished to sterilise. Heat is produced by the employment of a Bunsen burner, or a small gas stove placed underneath the boiler, or by connection with a system of superheated steam Openings are placed in the upper part of the metal cylinder which allow the steam generated in the boiler to pass into the inner sterilising chamber from the space between the two cylinders. The steam can escape by a pipe below, and it may be conducted through a coil of metal tubing placed in a bucke of water, where it is condensed.

In order efficiently to sterilise dressings, operation gowns, etc.

it is necessary that they should be submitted to a temperature of at least 100° C. in the steriliser for not less than half an hour.

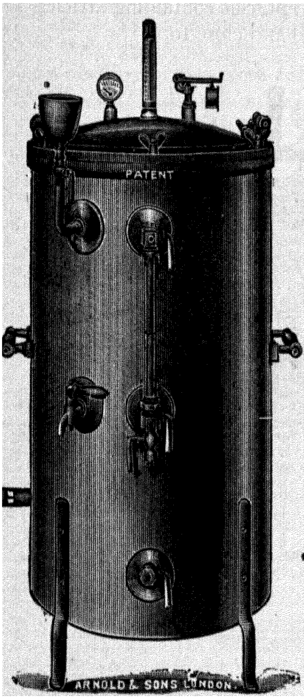

Fig. 15.—High-pressure steam steriliser for dressings, etc.

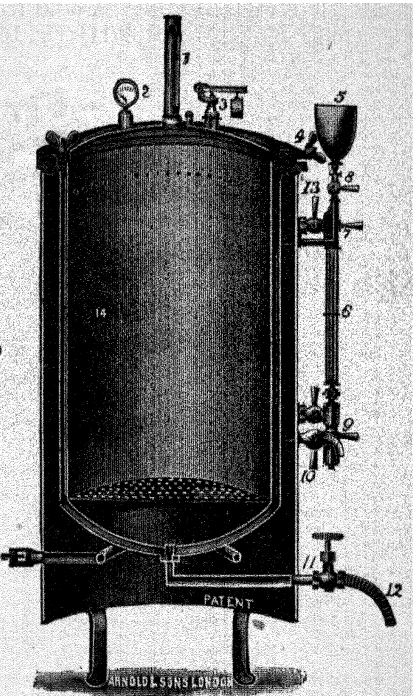

Fig. 16.—Section of high-pressure steam steriliser, to show construction, method of working, and constituent parts.

1. Thermometer.
2. Pressure gauge.
3. Safety valve.
4. Thumb screw.
5. Filling cup.
6. Water gauge glass.
7. Water gauge valves.
8. Filling cup valve.
9. Water gauge valve.
10. Drainage tap.
11. Exhaust valve.
12. Flexible tube for exhaust.
13. Water gauge valve.
14. Container.

The employment of a high-pressure steam steriliser allows the temperature to be raised considerably above the boiling point. For practical purposes, the temperature within the steriliser, when the pressure gauge registers

5 lb. . . . . . is 110° C., or 230° F.
10 „ . . . . . is 115° ·5 C., or 240° F.
15 „ . . . . . is 121° C., or 250° F.
20 „ . . . . . is 126° ·5 C., or 260° F.

General directions for use of steam steriliser (Figs. 15 and 16)—

1. Place kettles, bags, or other receptacles containing articles to be sterilised in space (14) (Fig. 16) and close top.

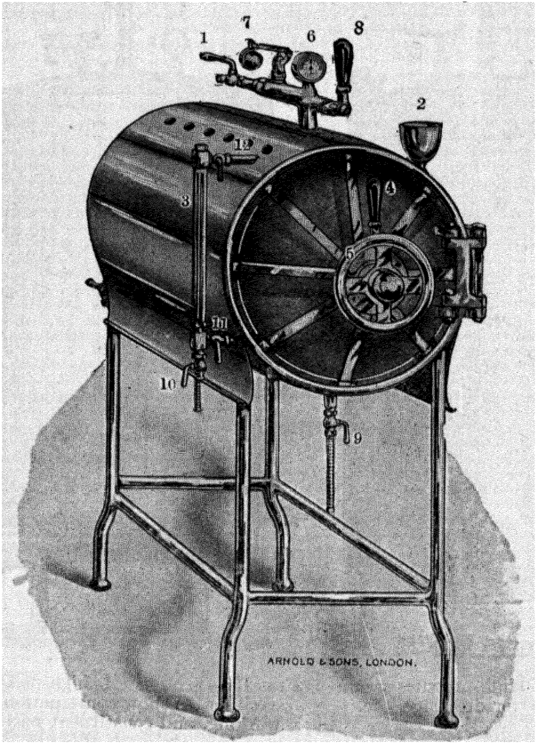

Fig. 17.—Horizontal steriliser.

1. Exhaust valve.
2. Filler.
3. Water gauge glass.
4. Handle for working arms.
5. Wheel for locking door.
6. Pressure vacuum gauge.
7. Safety valve.
8. Lever for working combined valve.
9. Valve for draining condensed water.
10, 11, 12. Valves for water gauge.

2. Fill jacket of steriliser through funnel (5) with hot water until mark on water gauge (6) is reached.

3. Turn off tap (8), turn on gas tap, open tap (11), and light gas, or turn on supply of superheated steam.

4. When hot air has escaped and steam appears in pipe (12), close tap (11).

5. Sterilise for twenty to thirty minutes and then open exhaust valve (11) to allow steam to escape and pressure to go down.

6. Remove cover, turn off gas, remove kettle from steriliser.

This appliance can be obtained in various sizes—large for hospital purposes, and medium or small for the use of a surgeon in private practice. In hospitals closely woven canvas bags can be used instead of metallic drums for containing dressings, etc. Every steriliser which is intended for private use ought to be large enough to contain kettles, each of which can be hermetically closed after sterilisation. One of these kettles contains operation gown, towels, wool, gauze, and dressings, and the other operation bowls. By the use of a suitably designed apparatus of this kind the appliances for an ordinary surgical operation can be sterilised before going to the place of operation.

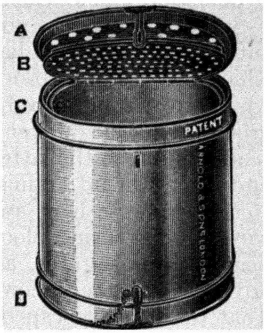

FIG. 18.—Kettle with arrangement for layer of cotton wool between dressings and exterior.

A. Perforated outer layer of lid.
B. Perforated inner layer of lid.
C. Container.
D. Base of similar construction to top.

Between A and B there is placed a layer of cotton wool.

It is important that towels, operation gowns, etc., should not be folded too tightly before placing them in the steriliser, otherwise there is difficulty in ensuring that the interior of everything is made absolutely sterile. The technical details which are of importance in working the steam steriliser are explained in the description of the steriliser and its "kettles" or "drums" (Figs. 15, 16, 17, 18, and 19).

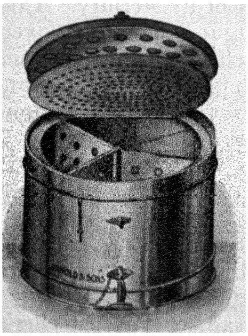

FIG. 19. "Kettles" for steam steriliser. These are air-tight when the lids are fastened down.

Another method of sterilisation of towels, etc., is by soaking in a solution of carbolic acid, usually 2 per cent. This is easy of application, but is extremely inefficient; hence it is not recommended. In emergency work, when it is impossible to obtain the use of a steam steriliser, towels may be soaked in a solution of biniodide of mercury solution, 1 in 1000, before being used for protecting an operation wound and its surroundings from being contaminated.

Selection and sterilisation of ligature and suture material.—Substances which are suitable for use as ligature and suture material may be divided into two classes—(*a*) Those which are readily absorbed by animal tissues, and (*b*) those which are not absorbed, and are permanent. To the former group belong the different preparations of " catgut " and animal tendons, and to the latter, silk, silkworm or salmon gut, cotton and linen thread, ramie fibre, and celloidin thread (Pagenstecher's), horse hair, and silver or aluminium covered copper wire. For securing blood vessels, and for all forms of buried ligatures and sutures, an absorbable material is theoretically advisable, if the following requirements can be fulfilled:—That the material can be readily and efficiently made *aseptic*, and that it shall not be *absorbed* before the tissues it holds together have had time to unite firmly, or, in the case of blood vessels, until the lumen has been permanently occluded. Catgut, properly prepared and of a thickness suitable for the individual case, can be made to fulfil all these requirements ; but it presents more difficulties and requires greater care in its preparation and use than some of the non-absorbable ligature materials, such as silk. On this account, silk, linen thread, or cotton thread has, to some extent, replaced the use of catgut. Some surgeons have entirely given up the use of catgut, on account of the difficulties experienced in making certain of its sterility. I do not think, however, that the use of " catgut " should be given up, as there are many instances in which it presents distinct advantages over silk, linen, or cotton. In practice the following rules, as regards the employment of " absorbable " and " non-absorbable " ligatures and sutures, will be found useful.

1. Sterilised catgut should be used for the ligature of blood vessels and for buried sutures, in all operations where the area of operation is already septic.
2. Sterilised catgut should be used for the ligature of blood vessels and for buried sutures, whenever the tissues involved are the seat of frequent or extensive movements.
3. Sterilised silk, linen, or cotton thread, or Pagenstecher's celloidin thread of suitable thickness may be used for the ligature of blood vessels, and for buried sutures and ligatures, in all operations where the field of operation is aseptic, with the exceptions mentioned in 2 and 5.
4. Silkworm or salmon gut of suitable thickness should generally be used for the closure of skin wounds, with a few

exceptions, such as the use of horse hair for the face and fine silver wire in certain cases of cleft palate.

5. Silver wire or aluminium covered copper wire of suitable thickness should generally be used for the approximation and fixation of bones, such as in the operations for fracture of the patella or the long bones of the limbs.

6. Metallic clips may be used for the closure of skin wounds. In my opinion, they do not possess any material advantages over sutures.

Sterilisation of silk, cotton or linen thread, and celloidin thread.—This can be carried out most efficiently by first winding the silk or thread on a glass or metal reel, of the shape shown in Fig. 20, in which there are numerous perforations in the hollow stem, and then boiling in water for twenty to thirty minutes. Many special sterilisers have been designed for this purpose. A small enamelled iron saucepan, however, is the simplest and best. In practice it is often found convenient to sterilise the ligature silk, etc., along with the instruments, in which case soda should not be used.

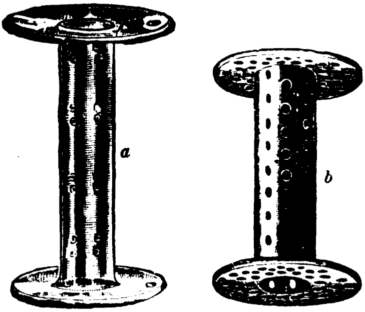

FIG. 20.—Perforated ligature reels.
a. Glass. *b*. Metal.

Horsehair and salmon gut are easily and effectively sterilised by boiling. They should not be wound on reels; it is sufficient to wrap them up in a long piece of gauze before placing in the steriliser.

Silver wire is sterilised by boiling in a solution of carbonate of soda, 1 per cent.

Sterilisation of catgut.—Catgut cannot be boiled in a 1 per cent. solution of carbonate of soda in water without being practically destroyed; it loses its extensibility and becomes friable, so that, when any tension is exerted upon it, the strands break. Several other procedures, however, are available for rendering the substance quite sterile. The most efficient are those which are known as the " xylol," " formalin-cumol," and " cumol " methods, of which the cumol method is probably the best.

Xylol method.—A special form of steriliser or sterilising tube is necessary. Figs. 21 and 22 are illustrations of the appliances which may be used for the purpose. The raw catgut is wound round a metal or glass plate, or piece of wood, of the shape shown in Fig. 23. The gut should not be wound tightly. First these plates are placed for several hours in a dry-air oven at a temperature of 70° C. in order to render the catgut as anhydrous as possible. Next, the metal plate and catgut are placed in the sterilising tube containing xylol (Fig. 21), the top tightly screwed on, and then the entire tube is placed in an ordinary water or steam steriliser, where it is left for twenty minutes to half an hour. The sterilising tube is then removed from the steriliser, the plate with the catgut removed from the interior of the tube, shaken free of all adherent xylol, and then placed in a glass jar containing a spirit solution of mercury biniodide 1 in 500 (75 parts of methylated spirit to 25 of water). In this it is kept until it is required for use.

For hospital purposes, the form of steriliser shown in Fig. 22 is useful. It consists of an ordinary water steriliser, with an inner vessel in which the xylol and catgut are placed. The top of the inner chamber should have a tightly fitting lid, which will prevent any possibility of the contents taking fire. Some surgeons have suggested that the fluid in the water chamber should be a saturated solution of ammonium sulphate in water. This boils at over 120° C., hence the temperature of the xylol is raised beyond that of the boiling-point of water. (Xylol boils at 148° C.) This, however, is not necessary.

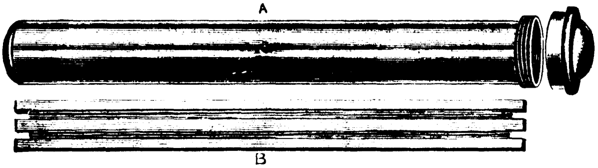

FIG. 21.—Tube steriliser for preparation of catgut by xylol method.

A. Tube.
B. Metal plate on which catgut is wound.

Formalin-cumol method.—Commercial raw catgut is wound on a glass, metal, or wood plate, as in the xylol method. It is first washed and brushed with soap and water, and then placed in a 4 per cent. solution of formalin in water. Here it is left for about ten hours, then taken out and thoroughly washed in sterilised water, so as to remove the formalin. The strands of catgut are now placed in a hot-air bath which is gradually heated to 80° to 85° C., and kept at this temperature for two hours. After being thoroughly dried in this manner the catgut is placed in a metallic bath or steriliser containing cumol. This vessel is placed upon a sand bath and heated to 160° C., at which temperature it is kept for thirty to forty-five minutes. The catgut is taken out of the bath and shaken free of adherent cumol and placed in sterile glass tubes, in which it is kept until required for use.

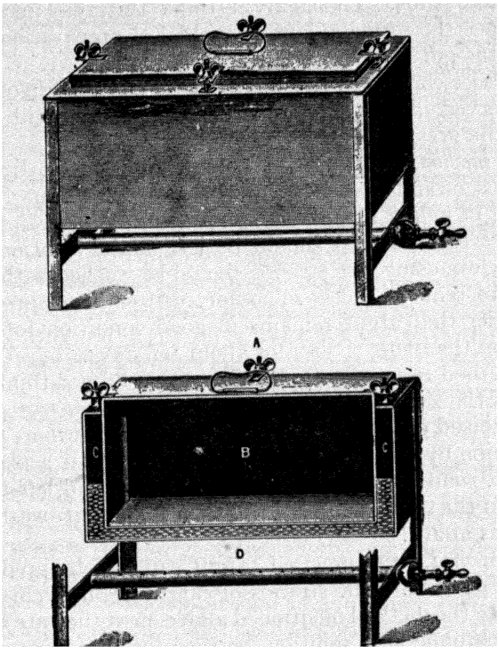

Fig. 22.—Large steriliser for xylol method of preparing **catgut.**

A. Cover of xylol chamber.
B. Inner chamber containing xylol.
C. Outer chamber containing water or solution of ammonium sulphate.
D. Gas burner.

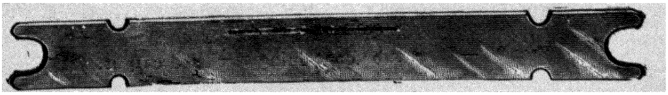

Fig. 23.—Plate on which catgut is wound.

Both these methods are quite reliable, and the surgeon can depend upon the material being absolutely sterile when it has been treated thus. Personally I think the xylol method the better, since the formalin-cumol method of preparation is liable to make the gut friable.

In practice, however, catgut prepared by the cumol method and preserved in hermetically sealed glass tubes will be found to be of the greatest use.

Iodine method.—Catgut can be rendered sterile by placing the washed strands, when wound on glass plates, in a solution consisting of iodine 1 per cent., potassium iodide 1·75 per cent. in water. The material should be left in the solution for ten days. Before using, the strands should be washed with alcohol, in order to remove excess of iodine. After being prepared in this manner the catgut remains in good condition for surgical purposes in the living tissues for about ten days.

This method is easy of application, but I do not think it is so reliable as the xylol method.

Chromicised catgut.—In order to make catgut more resistant to absorption by the tissues: before sterilisation it is placed in a 4 per cent. solution of chromic acid in water, and left there for eighteen to thirty-six hours. It is then taken out, washed, and sterilised as above.

Iodine method.—Chromicised catgut can also be prepared by the iodine method. The strands of catgut are first chromicised according to the method mentioned above, next they are removed from the chromic acid solution, washed in sterile water, dried, and then placed in the solution of iodine for ten days. Catgut prepared in this manner will remain good for about twenty-one days in the living tissues.

Catgut, chromicised and non-chromicised, efficiently sterilised and hermetically sealed in glass tubes containing alcohol, cumol, xylol, or chloroform, can now be obtained as a commercial article from most dealers in surgical supplies (Fig. 24). Before using, the exterior of the glass tubes can be sterilised by boiling, the tubes are then broken and the catgut removed ready for use. The catgut preserved in chloroform will not stand boiling, and on this account is not recommended.

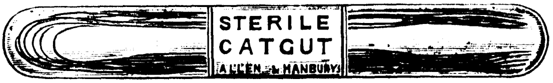

FIG. 24.—Glass tube containing sterilised catgut.

Kangaroo and Wallaby tendons.—The tendons of the tail of the kangaroo and wallaby have been used as absorbable sutures and ligatures. This material is expensive, and in my opinion does not present any advantages over well-prepared catgut. It is, moreover, still more difficult to render sterile.

Cotton thread.—Cotton thread has been used as a non-absorbable ligature material. It presents no advantages over silk, and is not so reliable. In emergencies, however, it may be used instead of silk. It is sterilised by boiling in water.

Linen thread.—This may be used. It is stronger than cotton thread of corresponding size, and is more reliable than much of the surgical silk now obtainable.

Celloidin thread.—This thread, made from celloidin, is used by many surgeons in place of silk or catgut. Its use can be recommended, but it must be remembered that if frequently boiled it frays and becomes almost useless.

Reels of cotton thread, linen thread, and celloidin thread should be boiled in water for twenty to thirty minutes, according to size of reel.

Cleansing, disinfection, and sterilisation of the hands and forearms of the operator, assistant, and nurse.—There is no doubt that the efficient disinfection of the hands and forearms of the surgeon, assistant, and nurse is one of the essential factors in the performance of a successful aseptic operation. The following method I have found, by long experience, to be quite efficient and easy of application :—

(*a*) The finger nails are cut short and all macroscopic particles of dirt or débris removed from underneath them by the use of a metallic nail-cleaner (Fig. 25).

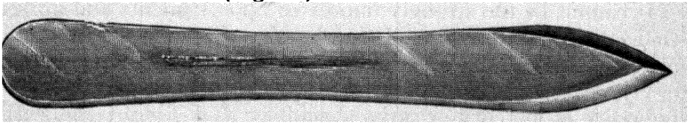

FIG. 25.—Metallic nail-cleaner.

(*b*) The skin of the hands and forearms is thoroughly washed and scrubbed with a sterilised flesh brush, for five minutes, in a stream of hot water and soap—soft soap or surgical soap being the most effective. (Specially prepared potash soap can be obtained in collapsible tubes or jars. This is the best for the purpose.) The brush, after sterilisation, should be kept in a solution of mercury biniodide, 1 in 1000, or 5 per cent. carbolic lotion, in a glass brush box, of the shape illustrated in Fig. 26.

(*c*) The skin of the hands and forearms is well washed with a mixture of potash soap and turpentine, or ether soap, in order to remove sebaceous material, grease, and fats from the surface of the skin and the openings of the sebaceous and sweat glands. (Ether, petrol, benzine, alcohol, or xylol may be used instead of turpentine.)

Ethereal soap (a combination of soap and ether) is a very useful and efficient agent for removing fatty and other substances from the skin, and is especially useful when the skin does not tolerate the mixture of soap and turpentine.

(*d*) Next, after the soap and turpentine or ethereal soap have been removed by washing in a stream of warm water, the skin of the arms and hands is soaked in or washed with an alcoholic solution of biniodide of mercury, of the strength 1 in 500, for two minutes. (This solution consists of 75 parts methylated spirit, 25 parts water and biniodide of mercury.)

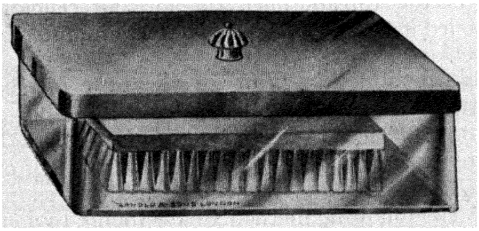

FIG. 26.—Glass box for brush.

(*e*) Finally, the hands and forearms are washed with normal saline solution or alcohol and dried with a sterilised towel.

It cannot be too strongly impressed upon students and nurses that efficient disinfection of the skin depends more on energetic mechanical brushing with hot soap and water, and turpentine or ethereal soap, than upon the use of chemical reagents such as biniodide of mercury or carbolic acid.

This method of preparation of the hands and forearms ought to be carried out in all cases, even in those which are known to be septic at the time of operation, otherwise fresh varieties of pathological micro-organisms may be introduced, and erysipelas, tetanus, or other acute infection superimposed upon that already existing.

The " fetish " of simply dipping the hands or even only the fingers into a bowl of carbolic or other lotion, before commencing or taking part in an operation, can best be stigmatised by saying that it is the completely futile proceeding of an uneducated and incompetent surgeon, who ought not to be allowed to perform any operation, even the opening of a superficial abscess.

Similarly, this habit must be avoided in the case of soiled hands, gloves, instruments, etc., during an operation.

Rubber gloves.—Thin rubber gloves (Fig. 27), which can be sterilised by boiling in water or in the steam steriliser, are now generally used by surgeons and their assistants during the performance of operations, in order to avoid infection of the wound from the skin of the operator. The use of these gloves is, however, accompanied by some disadvantages. The surgeon is not able to feel the parts he is operating upon so distinctly, and he may be hampered on this account in carrying out any delicate manipulations or dissections. An operator, however, very soon becomes accustomed to gloves, and can perform every manipulation practically as well with them as without them. Their use ought generally to be insisted upon, and especially when the operator or assistant has been in contact with a suppurating case, or if the hands are eczematous, or are the seat of slight scratches or abrasions.

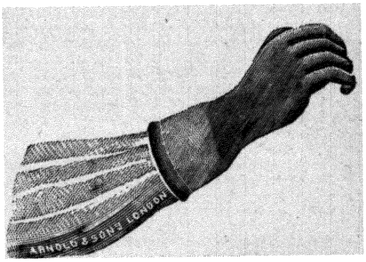

FIG. 27.—Rubber operation glove.

The sleeve of the gown of the operator's assistants should be made sufficiently long, so that it can be buttoned around the wrist and covered by the "gauntlet" portion of the rubber glove (Fig. 27).

Preparation of the skin of the patient within the field of operation.—On the afternoon of the day previous to operation the patient has a hot bath, and the skin all over the body is well scrubbed with soap and water. After the bath the skin of the patient within and around the field of operation is scrubbed with soft soap and hot water and shaved with a razor. Shaving is advisable in all cases, even when there is only a small growth of hair on the part concerned. It is a very efficient method of removing the sodden epithelium of the surface and its contained bacteria. Before the patient is brought to the operating theatre the area of operation is rubbed firmly with a swab soaked in ether or acetone. This has the effect of dissolving and removing fat and sebaceous matter, and (as Sir Frederick Andrewes has shown) sterilises the layers of the skin to a greater depth than is the case with such antiseptics as iodine and picric acid, which are not fat solvents.

After the patient has been anæsthetised the operation area is again scrubbed with ether, and finally painted with a 2½ per cent. solution of iodine in rectified spirit, or a 3 per cent. solution of picric acid in spirit. Iodine and picric acid, in addition to their sterilising properties, stain the skin, rendering apparent at once any unsterilised area should the towels require rearrangement.

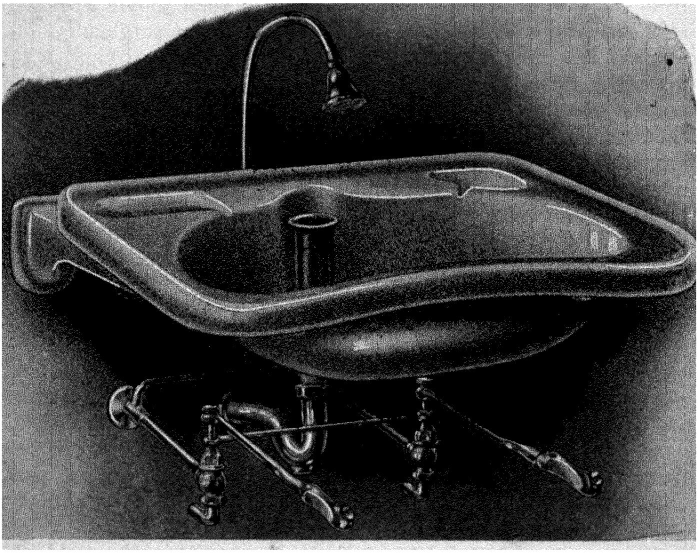

FIG. 28.—**Washing basin for operation room. The different taps have knee attachments so that they can be worked by the knees.**

When the skin within the field of operation is the seat of an ulcer, such as in a case of fungating carcinoma of the breast, or of an open sinus, an attempt should be made to sterilise the infected area, and shut it off from the operation wound. In the former case this can best be attempted by scraping away with a sharp Volkmann's spoon any granulation tissue which is evident, then cauterising the bare area with the actual cautery, or strong carbolic acid (90 per cent.), and finally covering the part either with a layer of sterilised gauze dipped in collodion, or by several layers of gauze which have been soaked in a lotion, such as mercury biniodde, 1 in 1000. This method of preparation is of course carried out after the patient has been anæsthetised. Ulcerating carcinomatous growths of the breast can be rendered less septic by repeated applications of a dilute solution of formalin, 2 per cent. or more, if not too painful, for some days before operation.

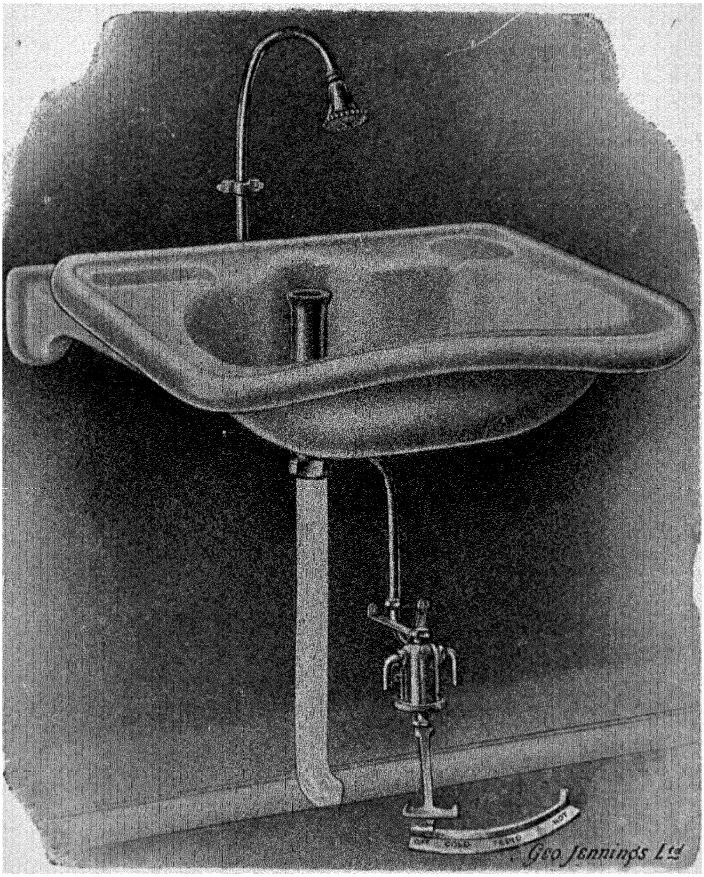

Fig. 29.—Washing basin for operation room. The taps have pedal attachments and can be worked by the feet.

In operations of emergency, such as for strangulated hernia, acute intestinal obstruction, or severe injuries, it is generally impossible to carry out in their entirety these preliminary precautions, owing to the necessity for the immediate performance of the operation. The skin, in these cases, in the neighbourhood of the field of the operation, is dry shaved, so as to free it from hair, and then made as aseptic as possible by first washing it with acetone or ether or turpentine, and then applying a 2·5 per cent. solution

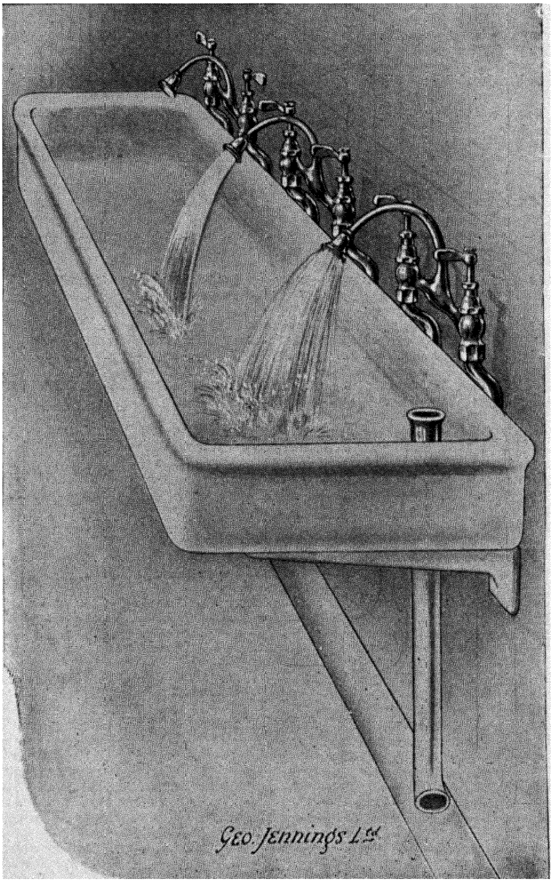

FIG. 30.—Long porcelain sink with three washing arms, fitted with spray and stream arrangements.

of iodine in alcohol, or 3 per cent. picric acid in alcohol, after the manner already mentioned.

Operation room or theatre.—In all properly equipped

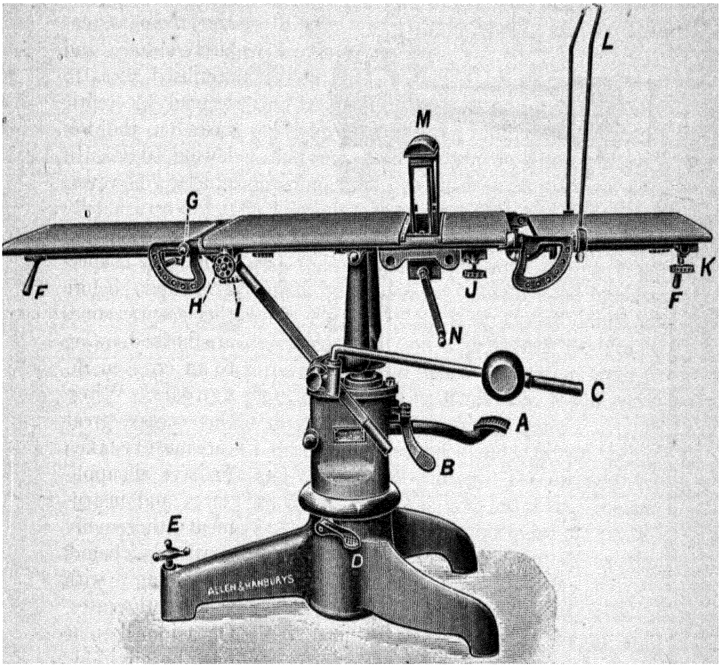

FIG. 31.—Operating table. St. Bart.'s operation table designed by author.

A Foot pedal for raising table.
B. Foot pedal for lowering table.
C. Lever for inclining table.
D. Foot pedal for enabling table to be rotated.
E. Foot rotation screw for fixing table.
F. Levers for working head and foot supports.
G. Fitting for enabling foot pieces to be removed.
H, *I*. Fittings for fixation of lithotomy stirrups or small instrument table.
J, *K*. Fitting for fixation of shoulder pieces.
L. Anæsthetic screen.
M. Back rest for liver, gall bladder, and bile duct operations.
N. Crank handle for raising or lowering back rest *M*.

hospitals one or more rooms are specially fitted up for operations. It is advisable in every hospital that there should be at least two theatres—one for aseptic cases, and the other for those in which suppuration is known to exist at the time when the operation is performed. When two separate theatres are not available, on each operation day the non-septic cases should be dealt with first and the septic ones afterwards. Then the room is entirely cleaned and sterilised, so as to be ready for aseptic cases on the following day. In practice, however, it will occasionally happen that a septic case is operated upon before the aseptic ones are finished, owing to an error in diagnosis. When this occurs, great care must be taken to have all appliances and instruments thoroughly sterilised before proceeding with the aseptic cases. Occasionally it may be advisable to defer the remaining operations until the following day.

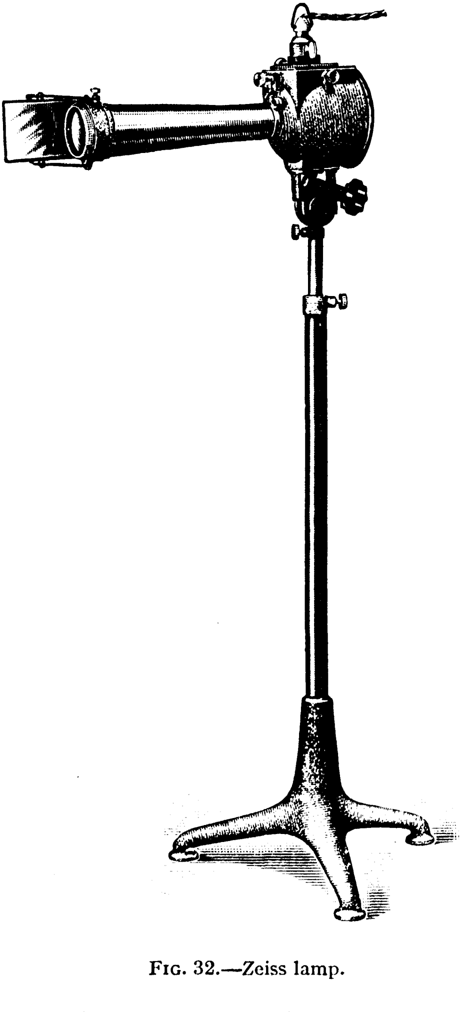

FIG. 32.—Zeiss lamp.

An operation theatre should be of convenient size, and have the walls, floor, and roof made of material which can be readily cleaned by mechanical means, and which does not readily absorb any form of liquid. The floor should be of cement or concrete, and the walls and that part of the roof, which is not occupied by windows, of the same material, or covered with glazed tiles or sheets of glass. The lines of junction of the floor and side walls, the junctions of the side walls themselves, and their union with the roof, should all have rounded corners and angles, so as to avoid any crevices or spaces which may readily become the lodging-places of dust, bacteria, etc.

LIGHT.—Every operation theatre should be placed on the top of the building, and be so arranged that there are both side windows and also a top light or window on the roof. This skylight should be fixed, and not made to open by cords, pulleys, etc. The side windows may be arranged so as to open for ventilation. Electric light should be installed and fitted, so that a strong light can be thrown on any part of the patient without interfering with the operator or his assistant. A very useful lamp for abdominal operations or where a good light is required is that shown in Fig. 32. This is an electric lamp on a stand with an adjustable stem and arm, which enables a strong light to be thrown upon the field of operation from a distance. Electric plugs should also be fitted, which will serve for supplying current to a cautery or an electric motor.

VENTILATION.—All draughts must be avoided, doors being made to fit closely and to open by sliding. The air may be changed by having an electric exhaust fan, for taking the air out, and the inlets so arranged that the incoming air passes through cotton wool, or is warmed and sterilised as by the Plenum system.

DISINFECTION.—This is carried out by washing with a solution of carbonate of soda, and by spraying steam and antiseptics on the entire surfaces of the walls, floor, roof, etc.

WARMING.—This is best effected by the employment of radiant heat, or by warming the incoming current of air, or on the "Panel System."

Perhaps the best system is to have the entire operation unit heated on the "Panel System." By this system the minimum of exposed hot-water pipes, etc., is necessary.

EQUIPMENT.—Every operation theatre, or series of operation theatres, should have in connection several other rooms, which may serve as dressing-room, anæsthetising room, recovery room, sterilising room, instrument room, pathological laboratory, and bath-room and lavatory.

The actual operation room should be fitted up with a proper operation table, a table for instruments, a table for lotions and sponges, a table for the equipment of the anæsthetist, and properly arranged sinks and washing arrangements. The taps and plugs of the sink and washing basins should have pedal or knee attachments, so that they can be worked by the feet or knees. These washing arrangements are for use during and between operations, and are not intended to be used in the first preparation of the arms and forearms of the surgeon, assistant, and nurse. It is preferable to use a spray or stream of warm water when washing, since by this means there is less liability of the skin remaining contaminated.

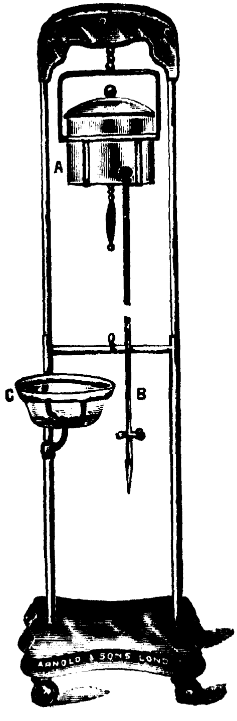

FIG. 33.—Irrigator on stand.

A. Receptacle containing fluid for irrigation.
B. Irrigation tube with glass nozzle.
C. Glass dish to hold the tube and nozzle when not being used.

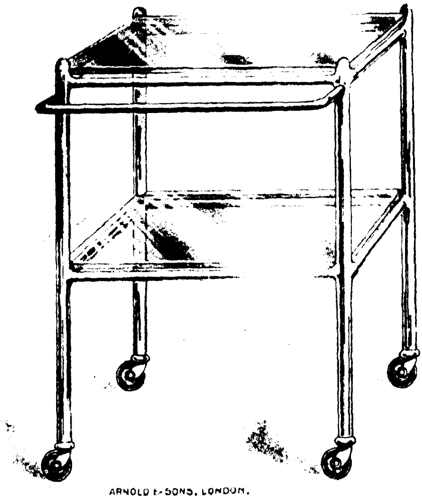
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FIG. 34.—Oblong metal table with glass top and shelf, for bowls, lotion, etc.

A very useful fitting for an operation room is shown in Fig. 30. This consists of a long porcelain sink over which there are thin metal arms. Each arm is controlled by two levers governing the supply of hot and cold water, and the extremity is fitted to act either as a spray or stream. A proper supply of bowls and trays of different sizes (Figs. 41, 42, 43) for lotions, sponges, and instruments, and one or more large jugs or an irrigator on a stand (Fig. 33) for use during irrigation, must be provided.

The choice of an operation table is a difficult one. It ought to be strong, non-complicated, capable of being warmed, readily cleaned, and fitted with arrangements (*a*) for placing the patient in the raised pelvic or " Trendelenburg " position ; (*b*) for inclination so as to raise head and neck to a higher level than rest of body ; (*c*) for raising and lowering and revolving entire table ; (*d*) for raising central portion of trunk, as in operations on liver and biliary system ; (*e*) removable arm rests for use in operation on upper extremities. Fig. 31 is an operation table which possesses most of the requirements of operative surgery. Figs. 34 and 35 are illustrations of tables which are the most suitable

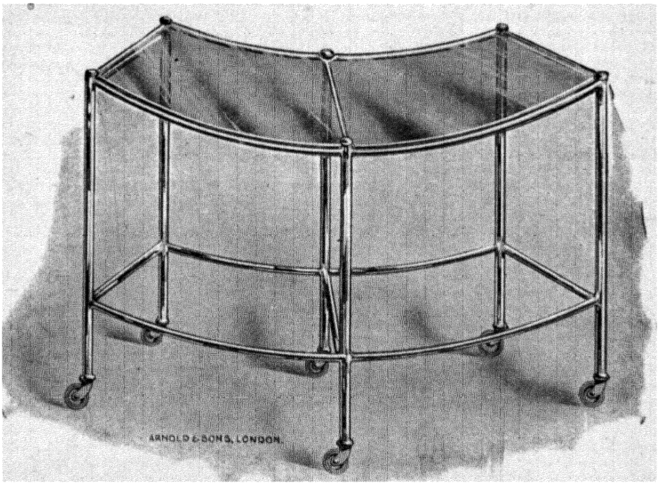
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Fig. 35.—Curved metal table with glass top and shelf, for instruments.

for instruments, lotions, etc. The curved table is for the trays containing instruments and ligatures, and is placed on the side of the operator ; the oblong one, for bowls containing sponges and lotions, is on the side of the assistant and nurse.

They are made of enamelled iron or polished brass and plate glass.

A supply of sterilised water must be at hand, and also materials for making the various antiseptic lotions which are used in the practice of aseptic and antiseptic surgery. Several methods of sterilising water or saline solution for use in operation theatres are adopted. One is by boiling in a copper vessel, a second by the use of superheated steam in connection with steam heating, and a third by the use of a filter, such as those

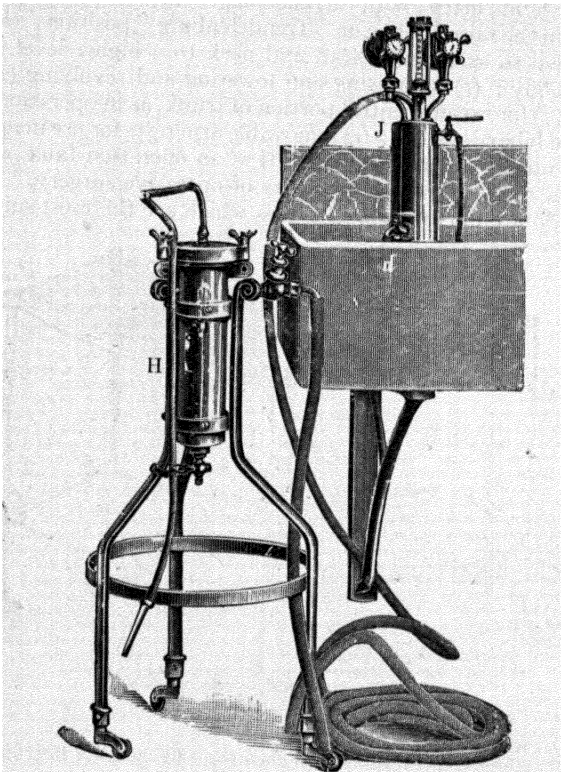

Fig. 36.—Berkefeld aseptic filter. An apparatus for supplying sterilised water of regulated temperature for use in surgical operations. It consists of two parts, namely, the copper cylinder J and the Berkefeld filter H. The former contains a copper coil thickly tinned inside; through this coil hot water passes from the hot water supply, and as this is generally too hot for use in surgical operations it can be tempered by filling the space around with cold water. By passing more or less cold water through the cylinder, and with the aid of the thermometer, the temperature of the water in the coil can be regulated to any required degree.

known as Berkefeld or Chamberland (Fig. 36). The former filter, when carefully looked after, appears to be reliable in providing sterile water. The "ideal" arrangement, however, in my opinion, is to have the water sterilised either by boiling or by superheated steam, and kept in a convenient reservoir, and to have a tap or pipe of supply in the actual operation room. Fig. 37 is an illustration of a simple copper boiler which is used for the preparation of sterilised water in connection with the operation theatres of hospitals.

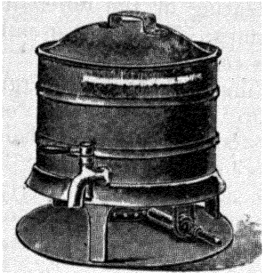

FIG. 37.—Copper boiler, for use in producing sterilised water.

Fig. 38 is an illustration of an apparatus in which the different sterilisers are fitted on one stand.

Fig. 40 shows a set of sterilisers for dressings, instruments, bowls, water, saline solution, aprons, gloves, etc., suitable for the operation theatre of a hospital or properly equipped private nursing surgical institution. When

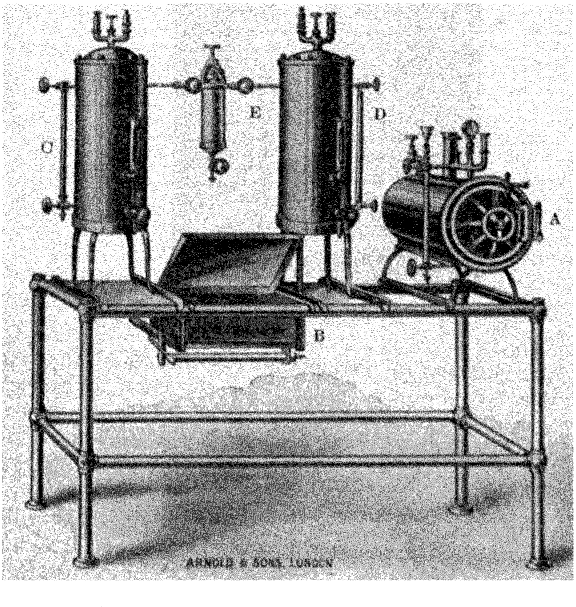

FIG. 38.—Combined fitting for small operation theatre.

A. Steriliser for dressings, bowls, etc.
B. Instrument steriliser.
C, D. Water and saline sterilisers.
E. Filter.

a room immediately adjacent to and communicating with an operation theatre is available, the different sterilisers can be arranged as shown in Fig. 40. The heating of the different sterilisers can be by steam, gas, or lamps. The most useful method is by superheated steam, from a central system.

Every operation theatre ought to be under the direct charge of a trained surgical nurse. There are so many details of cleansing which are more readily understood by a woman than by a man, that it appears to me to be more fitting for this part of the arrangements to be placed under a nurse. A properly trained surgical sister or nurse who understands the technique of modern surgery is indispensable to a successful surgeon. In fact, one feels justified in stating that the success of an aseptic operation depends almost as much upon the nurse as upon the surgeon.

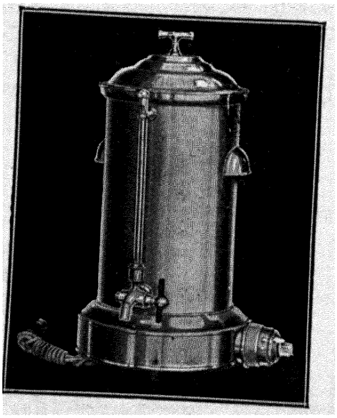

FIG. 39.—Water steriliser. Heated by electricity.

Solutions.—The following solutions are those which are most frequently used, and the most useful and efficacious in surgical operations :—

1. *Normal salt solution.*—This is made by adding to sterilised water 0·9 per cent. of sodium chloride. For emergencies a teaspoonful of salt, added to a pint of water, represents, for all practical purposes, the strength of this solution.
2. *Picric acid.*—3 to 5 per cent. in alcohol.
3. *Iodine.*—2·5 per cent. in ethyl alcohol (not methylated spirit).

4. *Biniodide of mercury.*—This is generally used as a solution having a strength of 1 in 2000 or 1 in 4000. The addition of a small quantity of potassium iodide facilitates the solution of the salt in water.

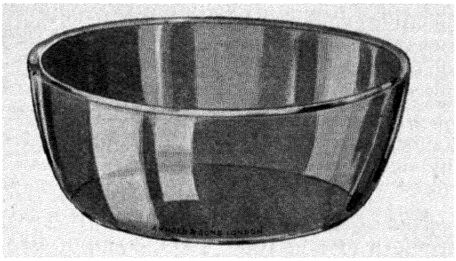

Fig. 41.—Round bowl (of glass, enamelled iron, or

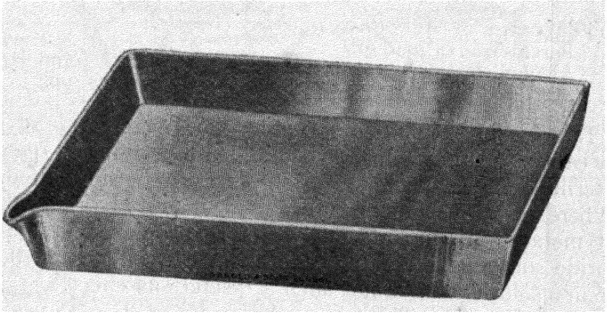

Fig. 42.—Flat tray (of glass or enamelled iron) for instruments.

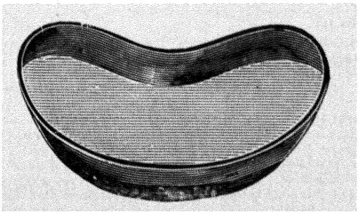

Fig. 43.—" Kidney " shaped bowl (of glass, porcelain, or enamelled iron) for use during irrigation, or when opening abscesses, cysts, or other fluid-containing tumours.

Biniodide of Mercury Solution (1 in 2000)—

Biniodide of mercury	0·5 grm.
Iodide of potassium	1 ,,
Sterilised water	1 litre.

Biniodide of Mercury Solution (1 in 4000)—

Biniodide of mercury	0·25 grm.
Iodide of potassium	1 ,,
Sterilised water	1 litre.

Biniodide of Mercury Solution (1 in 500)—

Biniodide of mercury	2·0 grms.
Methylated spirit	0·75 litre.
Sterilised water	20·5 ,,

5. *Perchloride of mercury.*—This reagent is used in solutions having a strength of 1 in 1000, 2000, 3000, or 4000. The salt is not very readily soluble in water, and in order to facilitate its solution a small quantity of alcohol is added.

Perchloride of Mercury Solution (1 in 1000)—

Perchloride of mercury	1 grm.
Alcohol	100 grms.
Sterilised water	900 ,,

"Tabloids" of biniodide of mercury and perchloride of mercury can be obtained which, when added to a sufficient quantity of sterilised water, make a solution of the strength required.

When solutions of mercury are used, it must be remembered that metallic instruments ought not to be placed in the perchloride solutions, since they are affected by it. Biniodide of mercury solutions have not such a deleterious effect.

6. *Carbolic acid.*—This is usually used as a 2½ or 5 per cent. solution.

Carbolic Acid Solution (5 per cent.)—

Carbolic acid	50 grms.
Glycerine	50 ,,
Sterilised water	1 litre.

Carbolic Acid Solution (2½ per cent.)—

Carbolic Acid	25 grms.
Glycerine	25 ,,
Sterilised water	1 litre.

Carbolic Acid Solution (90 per cent.) (for use as a caustic)—

Carbolic acid	90 grms.
Sterilised water	10 ,,

Many other chemical antiseptics are used by different surgeons, such as formalin, lysol, izal, iodoform, iodine, boracic acid, chloride of zinc, creolin, etc. For special purposes many of these are useful, but for general routine surgical work the solutions mentioned above will meet nearly all requirements.

An improvised operation room.—It is often necessary, in emergency work and in private practice, to perform a surgical operation in a private dwelling-house. A room should be selected as an operation room which is well lighted (a top light if possible), and can be well warmed. A little-frequented room of moderate size is the best. The room should, if possible, be prepared the day preceding the operation, and then closed. Curtains, pictures, in many cases carpets, and all unnecessary furniture must be removed. Every part of the room is well brushed and dusted, so as to remove all dry dust. Next, the floor, walls, and windows and door are washed and scrubbed with a hot solution of washing soda, and then scrubbed with a solution of perchloride of mercury, 1 in 1000. Some recommend that a 5 per cent. solution of carbolic acid should be used instead. Personally, I think the perchloride of mercury solution is the more effective. When the room is prepared on the day previous, disinfection by the formalin method may be employed. It is very efficacious, but requires many preparations for carrying it out.

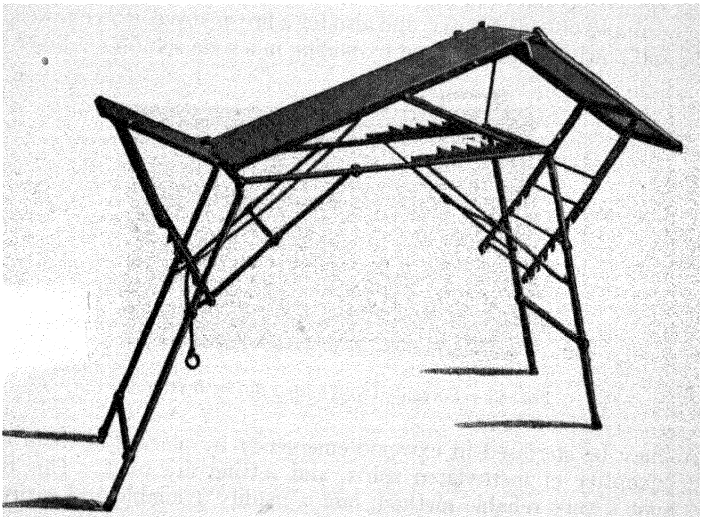

FIG. 44.—Portable operation table made of nickel-plated steel tubing with zinc top, showing the table with head end raised, arranged for the raised pelvic or Trendelenburg position. (Designed by Author.)

The danger of infection from micro-organisms floating about in the air may be minimised considerably by steaming the room with a jet of steam. When the room has been prepared the windows and doors are closed, and it is left until the next day.

As regards an operation table, if a portable operation table is not available, a strong kitchen table, as narrow as convenient, should be selected, and prepared in the manner described for the room. Fig. 44 illustrates a compact form of metal operation table which is quite portable, since it packs into a very small compass as shown in Fig. 45. Arrangements should be made for a supply of boiled water, and also for a fire or stove, where towels and bowls can be sterilised by boiling in a soda solution. Bowls may be sterilised in extreme emergency by placing in them a quantity of methylated spirit, and setting fire to it. This is not a very reliable method, but is readily available and easily applicable.

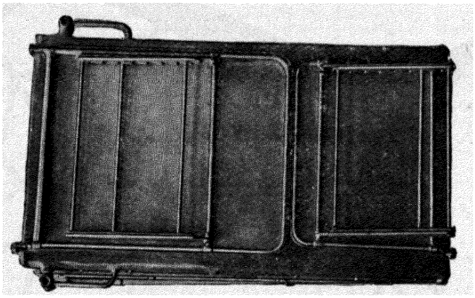

FIG. 45.—Portable table folded up for travelling.

The trained surgical nurse is of great assistance in the preparation of rooms for an operation. She understands more perfectly than a man many household duties which are necessary for undertaking work of this kind. There is no doubt that in many cases of emergency operations, and operations performed in private dwellings, the trained nurse performs the most difficult task when she makes all the necessary arrangements and preparations which are essential for the success of the proceeding.

Preparation of patient for anæsthesia.—An aperient medicine should be given, if possible, on the day preceding the operation, and an enema on the morning of the operation, so as to evacuate the intestines ; this is especially necessary before operations on the abdominal portion of the alimentary canal, or upon the rectum. No food should be given by the mouth for three or four hours before the operation is performed. In patients of nervous temperament the digestive functions of the stomach may be considerably delayed, necessitating starvation of twelve hours before operation. Proper observance of these precautions tends to avoid vomiting during the administration of the anæsthetic, and also involuntary evacuation of the fæces. When the alimentary canal is the seat of operation, it is a great advantage that it should be as empty as possible so that the possibility of soiling the peritoneum with intestinal contents may be minimised. In many abdominal operations, especially those which involve the pelvic viscera, it is advisable to empty the bladder immediately before or after the commencement of the administration of the anæsthetic. This can be done either by directing the patient to pass water shortly before coming to the operation room, or by passing a catheter when the anæsthetic has been given.

LOCAL ANÆSTHESIA

Local anæsthesia is obtained by blocking the transit of impulses over the sensory nerves to the brain. This may be effected by the action of drugs (1) upon the receptive end-plates, (2) upon the trunk of the nerve, (3) upon the sensory tracts in the cord.

Methyl salicylate made into an ointment with lard and rubbed into the skin produces a certain degree of local anæsthesia by its action on the end-plates. A more complete local anæsthesia of the skin may be obtained by freezing it with an ethyl chloride or ether spray. Nerve trunks and filaments may be " blocked " by the injection into their sheath (endoneural), or neighbourhood (peri-neural), of a solution of cocaine, novocain, stovaine, or similar drug.

In order to block the sensory tracks in the cord, lumbar puncture is performed, and a solution of novocain or stovaine is injected into the theca in place of a few c.cm. of cerebro-spinal fluid which are previously withdrawn.

Properties of local anæsthetics.—The ideal local anæsthetic should be readily soluble in normal saline solution, and rapid and certain in its action. It should produce an anæsthesia which will last long enough for the performance of a major operation. It should be non-irritant and non-toxic. It should not decompose with heat, so that a solution may be sterilised by boiling.

The drug that most closely fills the conditions above is novocain; it is far less toxic than cocaine and also less irritant. It is readily soluble in saline, and the solution may be boiled repeatedly. Its weak point is that it is quickly absorbed and therefore rapidly loses its anæsthetic action; this, however, may be corrected by mixing a little adrenalin with the solution. Adrenalin, by constricting the blood vessels, localises the action of the anæsthetic, prolongs its period of activity for two to three hours; it also has the advantage of minimising hæmorrhage during the operation.

The solutions used are novocain ½ per cent. to 4 per cent. in normal saline solution with the addition of adrenalin ($\frac{1}{1000}$) ♏ij ad ʒi.

With the weaker strengths, ½ per cent. and 1 per cent., almost unlimited quantities of the solution may be used; but with the higher concentrations the dose should not exceed ʒij of the solution.

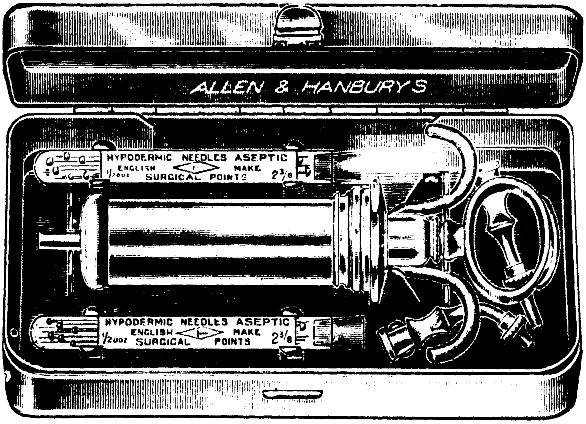

FIG. 46.—Syringe (Gray's) for injection of local anæsthetics.

Instruments.—Syringes of from 2 to 10 c.cm. capacity with glass or metal plungers are best. The barrel must be fitted with rings or some other form of finger grip, to enable the operator to get sufficient and steady pressure on the plunger. Needles should be fine, sharp, smoothly bevelled, and, above all, they should fit accurately to the syringe, so that the joint is absolutely air-tight. Occasionally it is convenient to use a connection which will permit of the needle being used at an angle to the long axis of the syringe (Fig. 46). If the syringe or needles are sterilised by boiling in water with sodium bicarbonate, it is essential that they should be carefully rinsed afterwards with pure sterile water, as traces of bicarbonate of soda will decompose the novocain.

Local anæsthesia by skin infiltration.—*Technique.*—This method is suitable for operations involving the skin only in cases in which there are no acute inflammatory changes, *e.g.* cutting Thiersch grafts.

The whole area of operation is rubbed with methyl salicylate ointment and then cleaned with ether. A syringe, varying in size according to the area to be anæsthetised, is selected and filled with ½ per cent. novocain and adrenalin, and a fine needle fitted.

The needle is introduced under the epidermis with its bevelled surface downwards and parallel to the superficial layer of the skin. As the novocain is forced out of the syringe a white weal marks its spread in the skin. The needle is advanced in the weal as the injection is continued. If a large area is to be covered, the needle will have to be withdrawn, and reintroduced at several different points. *It must always be introduced through an area already anæsthetised.* The whole of the operation area must be covered in this way, and anæsthesia is complete as soon as the injection is finished.

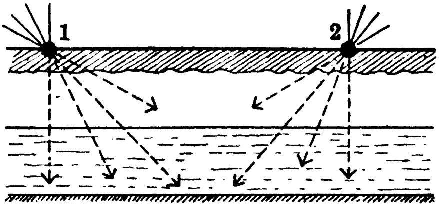

FIG. 47.—Method of infiltration.

Local anæsthesia by deep infiltration.—By injecting novocain along the walls of a prism of tissue all sensory impulses from within the prism will be blocked and the whole rendered anæsthetic. This method therefore is applicable for such operations as removal of foreign bodies, tumours, carbuncles, etc.

The area it is proposed to anæsthetise is marked out and a point for the insertion of the needle selected. If the operation area be large it may be necessary to select more than one such spot. A small syringe armed with a fine needle is selected and filled with ½ per cent. novocain and adrenalin. The needle point is inserted into the epidermis and a few drops of solution injected, a small, raised, white "button" being produced.

Similar " buttons," are, if necessary, raised at other selected points. A larger syringe filled with the same solution and armed with a larger needle is now taken. The needle is introduced vertically through the " button " and passed into the deeper tissues—the operator feeling his way through the consecutive layers to the required depth. As long as the needle is in progress, whether advancing or retreating, a constant stream of novocain must be injected, about 1 c.cm. of solution being required for each cm. traversed. The needle is retracted to the subcutaneous layer and then pushed in slightly more obliquely. This manœuvre is repeated until finally the needle passes horizontally in the subcutaneous layer. In this way a wall or section of tissue is anæsthetised. By repeating the process in two or more planes the operation area can be isolated.

Infiltration of a section of the soft parts.—The needle is introduced through two " buttons " (Fig. 47, 1 and 2) in such a way as completely to infiltrate the tissues in the selected section.

Isolation of a pyramid of tissue by injecting its sides.—When it is proposed to anæsthetise a pyramid of tissue of which the base (1, 2, 3, 4) is formed of skin, and the apex (5) is situated deeply in the soft parts, " buttons " are raised at 1, 2, 3, 4, a long needle is introduced successively at each " button," and injections are made first towards the apex of the pyramid (5) and then to different parts upon the sides of the pyramid, *e.g.* from 3 to 6, 4 to 6, 4 to 7, 1 to 7,1 to 8, 2 to 8, 2 to 9, 3 to 9.

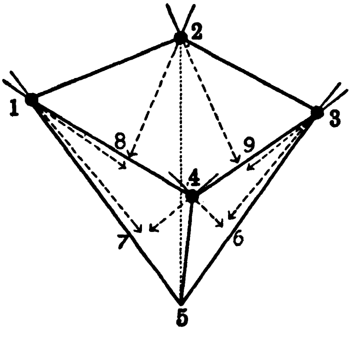

FIG. 48.—Method of anæsthetising a pyramid of tissue from four "buttons" (1, 2, 3, 4).—After PAUCHET and SOURDAT.

Endoneural injection.—This procedure may be carried out subcutaneously, or by direct vision after dissecting out the nerve through tissues previously anæsthetised.

Where the nerve has some definite and close relation to bone subcutaneous injection is not difficult, *e.g.* the ulnar nerve at the elbow-joint. But when the nerve is situated in the midst of soft tissues the operation is more formidable. The operator must rely upon the patient's sensation. A fine needle is passed through a " button " towards the site of the nerve, and when this latter is touched the patient feels a pain which radiates along the course of the distribution of the nerve.

The needle is plunged into the centre of the nerve trunks, and a few drops of 2 per cent. to 4 per cent. novocain injected until the nerve tracts, in the open method, can be seen to swell up and become white at the site of the injection. Anæsthesia of the tissues supplied by the nerve below the level of injection is produced immediately.

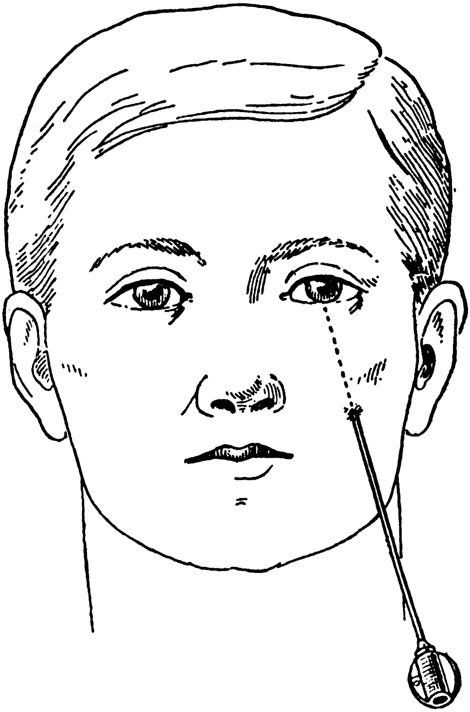

FIG. 49.—Injection of Gasserian ganglion.—After PAUCHET and SOURDAT.

Should the operator prefer to inject the novocain around the nerve, a solution of 2 per cent. to 4 per cent. must still be used, but an interval of about twenty minutes must elapse before anæsthesia be complete.

Infiltration of the ganglion semilunare (Gasserian) can be performed by injection through the foramen ovale.

Indications.—For operations upon the face under local anæsthesia the ganglion may be injected with 2 per cent. novocain. For trigeminal neuralgia the ganglion may be injected with alcohol.

Special instrument.—Hypodermic needle 10 cm. long.

Position.—The patient is sitting upright, and the operator sits opposite him.

Operation.—An anæsthetic " button " is raised 3 cm. lateral to the angle of the mouth. The needle is introduced through the " button " and, guided by a finger in the mouth is passed deep to the buccal mucous membrane upwards and backwards between the ascending ramus of the mandible and the tuberosity of the maxilla until the point impinges upon the floor of the subtemporal fossa. The point of the needle is now depressed. Great care must be taken to keep the needle exactly in the position recommended by Haertel. Seen full face, the needle must be in the same plane as the pupil of the patient when he is looking straight before him. Seen in profile, the long axis of the needle cuts the middle of the zygoma. As the point of the needle is depressed its axis changes to meet the zygomatic tubercle, and the patient experiences a radiating pain along the distribution of the N. mandibularis (inferior maxillary division of the fifth nerve). The needle now lies at the opening of the foramen ovale, and, carefully maintaining the needle in the same axis, the point is advanced 1 to 1½ cm., and about 1 c.cm. of the 2 per cent. novocain (or absolute alcohol) injected into the ganglion. The anæsthesia with novocain is almost immediate, and lasts for two or three hours.

Regional anæsthesia of the upper extremity.—Complete anæsthesia below the area supplied by the axillary and intercosto-brachial nerve may be obtained by infiltration of the brachial plexus above the clavicle.

Anæsthesia of the forearm and hand may be induced by intra- or peri-neural injection of the nerves at the bend of the elbow.

Infiltration of the brachial plexus above the clavicle.—*Position.*—The patient is in the sitting position, with the head supported by a rest and the arm on the affected side hanging down in order to depress the clavicle. The operator stands in front of the patient.

Special instrument.—A fine needle about 5 cm. in length.

Technique.—The subclavian artery is palpated as it passes downwards behind the middle of the clavicle, and the index finger of the left hand is placed over the vessel to guard it.

Immediately lateral to this point an anæsthetic "button" is raised.

The injecting needle, unattached to the syringe, is then introduced in a direction towards the spine of the third thoracic vertebra. The plexus is encountered immediately under the deep fascia, and is signalised by the patient (already warned), who experiences tingling sensations in the hand, generally along the distribution of the median nerve. If the needle penetrate to a depth of 3 cm. without encountering the plexus, it must be withdrawn to the subcutaneous layer and the direction slightly changed. If a vessel be pierced, blood will escape from the needle. When the plexus is located the syringe is attached to the needle and 10 c.cm. of 2 per cent. novocain with adrenalin injected. Another 10 c.cm. of novocain are injected as the needle is withdrawn. About fifteen minutes must elapse before anæsthesia is complete. If at the end of this period anæsthesia is not established, a failure must be recorded and the procedure repeated. The anæsthesia will last from one and a half to three hours.

Regional anæsthesia of the forearm and hand.—*Special instruments.*—Scalpel, retractors, pressure forceps, dissecting forceps, scissors, needles, aneurysm needle, silk and silkworm gut.

Position.—The patient is in the dorsal position, with the arm abducted and laid on a side table.

Technique.—Through three or four anæsthesia " buttons " the subcutaneous tissue is infiltrated with ½ per cent. novocain and adrenalin in the form of a band 3 inches wide passing round the elbow. In this way superficial branches of the nervus cutaneus antibrachii lateralis (musculo-cutaneous) and nervus cutaneus antibrachii medialis (internal cutaneous) will be blocked and the field prepared for dissection of the three main nerve trunks—median, radial, and ulnar.

The median nerve is next exposed at the bend of the elbow (see p. 612) and about 1 c.c. of 2 per cent. novocain and adrenalin injected into the sheath.

The radial and ulnar nerves are similarly exposed (pp. 610 and 611) and injected.

Regional anæsthesia of the lower extremity.—To obtain anæsthesia of the lower extremity it is necessary to inject five nerve trunks: nervus cutaneus femoris lateralis (external cutaneous), nervus femoralis (anterior crural), nervus ischiadicus (sciatic), nervus cutaneus femoris posterior (small sciatic), and nervus obturatorius (obturator).

Nervus femoralis lateralis (external cutaneous).—The nerve lies beneath the deep fascia about two fingers' breadth mesial and direct to the anterior superior spine of the ilium. A "button" is raised over this point, and the subcutaneous and subfascial planes injected with about 3 c.c. of 2 per cent. novocain and adrenalin.

Nervus femoralis (anterior crural).—The pulsation of the common femoral artery immediately below the inguinal ligament (Poupart's) is felt, and a "button" raised 1½ cm. lateral to this point. With the index finger of the left hand resting on the artery, the needle is introduced through the "button" perpendicularly to the skin until the fascia iliaca is reached. This can readily be recognised by the resistance it offers to the needle. The fascia is pierced, and contact with the nerve indicated by contraction of the quadriceps muscles. Three c.cm. of 2 per cent. novocain with adrenalin are injected in the neighbourhood of the nerve.

Nervus ischiadicus (sciatic).—It is very difficult to inject this nerve subcutaneously. An attempt may be made through a "button" placed just to the inner side of the mid-point of a line joining the great trochanter and the ischial tuberosity. The needle is passed directly backwards, and the injection only made when contact with the nerve is shown by muscular contraction. In the majority of cases it is better to expose the nerve (see p. 613) after subcutaneous infiltration and inject directly into its sheath.

Nervus cutaneus femoris posticus (small sciatic nerve).—This nerve lies under the deep fascia beneath the mid-point of a line passing the great trochanter and the tuberosity of the ischium ; it is anæsthetised by the injection in its neighbourhood of 2 c.cm. of 2 per cent. novocain with adrenalin.

Nervus obturatorius (obturator).—It is not feasible to inject this nerve directly, and anæsthesia is obtained by superficial and deep infiltration of the tissues on the inner side of the thigh, thus blocking all the branches of the nerve.

Spinal anæsthesia.—Spinal anæsthesia is obtained by the injection into the spinal canal of a drug which paralyses motor and sensory nerve fibres both within and without the cord.

Indications and contra-indications.—Spinal anæsthesia finds its greatest use in operations upon the lower abdomen and lower extremities. As anæsthesia rises in the trunk there is proportionate embarrassment of respiration, first the intercostal muscles being paralysed and, if the cord be affected as far as the fourth cervical segment, the diaphragm.

Blood pressure falls with the injection, and if the drug reaches up to the mid or upper dorsal region there will be " physiological section " of the splanchnic nerves, resulting in great dilatation of the vessels of the splanchnic area, so that the patient may " bleed to death " into his own blood system. For this reason this form of anæsthesia is contra-indicated in patients who have a low blood pressure or are suffering from shock. It should not be used in children, in nervous or hysterical adults, in patients suffering from sepsis or whose temperatures are raised : coma has supervened on injection in diabetic patients. It is of value in patients whose blood pressure is high or who have renal insufficiency.

Anatomy.—In adults the spinal cord ends opposite the lower border of the first lumbar vertebra, but the dural sac is patent as far as the third sacral segment. The most convenient place for injecting the sac without risk of injury to the cord is through the space between the third and fourth lumbar vertebræ. When the patient is in the dorsal position, and supposing the thecal canal empty, the solution will run downwards and distally, and collect in the sacral region. If the pelvis is raised 3 inches at the time of injection the fluid will collect in the mid-dorsal region.

Anæsthetic solution.—A solution injected into the spinal canal alters its position (1) by slow diffusion, (2) by shifting of the whole column of fluid in which it is suspended upwards, or (3) by gravitation. Gravitation plays the greatest part in this movement, and for this reason two standard solutions of anæsthetics are prepared—one lighter than cerebrospinal fluid and one heavier. By raising or lowering the pelvis the distribution of the anæsthetic in the thecal canal can be fairly accurately controlled. The light solution has one great advantage over the heavy : that the head is lowered, and that the fall of blood pressure associated with this procedure is to some extent counteracted. The drug most in favour for spinal anæsthetics is stovaine made up into a heavy solution : Stovaine 10 per cent., glucose 6 per cent., distilled water 85 per cent. (Allen); or a light solution (Babcock's solution):

Stovaine	0·08 grm.
Lactic acid	0·04 c.cm.
Absolute alcohol . . .	0·2 c.cm.
Distilled water . . .	1·8 c.cm.

The dose of the solution is 1 to 1·5 c.cm. for an adult.

Technique of spinal injection.—*Instruments.*—A spinal trocar and cannula which must have a short, sharp point, a syringe of 5 c.c. capacity to fit the cannula, a hypodermic syringe with fine needle. A light or heavy solution of stovaine and a little ½ per cent. novocain.

Position.—The patient is placed in the sitting position, with the head and back bent well forward ; or he may lie on one side, still with the back well arched.

The spine of the fourth lumbar vertebra is identified by marking in the inter-tubercular plane which crosses it, and an area of skin of several inches diameter is sterilised. The skin immediately above the fourth lumbar spine is infiltrated with ½ per cent. novocain, and the spinal trocar introduced through the skin midway between the third and fourth lumbar spines and half an inch lateral to the mid-line. The trocar must be held slightly obliquely with the point directed upwards and inwards at such an angle that it will reach the mid-line at a depth of 2 inches. The point of the needle is advanced, meeting with little resistance until the ligamentum flavum (sub-flavum) is reached. If bone be encountered the needle must be withdrawn an inch or more and inclined more obliquely. The ligamentum flavum (sub-flavum) is penetrated with a sharp movement and the trocar withdrawn, leaving the cannula in position. If the dura be penetrated cerebrospinal fluid will escape. If only blood escapes, the trocar must be replaced and the needle partly withdrawn and a new puncture made.

When the spinal canal is reached about 2 to 3 c.cm. of cerebrospinal fluid are allowed to escape, and the anæsthetic syringe connected to the cannula and the stovaine solution slowly introduced into the canal.

The cannula is now withdrawn and the puncture in the skin closed with a collodion dressing. The patient is immediately placed in the recumbent position with the head raised on a pillow, and the pelvis raised or lowered according to the specific gravity of the solution used and the area of operation.

After-effects of spinal anæsthesia.—Any lapse from the most rigid precautions of asepsis on the part of the operator or his assistants may result in septic meningitis and death of the patient.

Nausea and vomiting occasionally occur for a few hours after the anæsthetic, and sometimes intolerable headache persists for some days, with or without symptoms of meningismus.

Paræsthesia of the lower limbs may occur for some days, and there may be temporary loss of control of the sphincters.

CHAPTER III

GENERAL SURGICAL TECHNIQUE (*Continued*)

Position of patient, operator, and assistants.—The patient should be placed in a position that will at once ensure the greatest possible advantage being taken of all available light, afford a complete exposure of the field of operation, and in no way hamper the movements of the operator and his assistant. Care, however, must be taken that the respiration of the patient is not interfered with, and that room is allowed for the administrator of the anæsthetic. When arranging the operation table for a patient, especially when a metal or metal-covered operation table is being used, it will be found a great advantage to place on the surface of the table a thick cellular rubber pad, which will lie between the surface of the table and the coverings of the patient. This rubber pad serves two purposes—firstly, it helps to prevent any unnecessary pressure upon the nerves of the patient, and secondly, it assists the retention of heat and the patient is thus kept much warmer. In an operation where it is necessary to place the limbs in particular positions especial care should be taken to dispose them so that no unnecessary pressure either on the nerves or any body prominences is made.

The operator places himself in such a position that he can easily and readily get at the region which is to be operated upon, whilst the assistants are so placed that they can afford the greatest help to the surgeon without impeding his movements.

The assistant or assistants, especially when not well acquainted with the technique of a surgical operation, should receive explicit instructions from the surgeon as regards their duties. A good assistant in a surgical operation does what is required of him at the right moment, but otherwise does not interfere with the course of the operation.

Procedure immediately before operation.—1. Coat and collar of surgeon to be removed.

2. Shirt to be taken off and replaced by a short-sleeved

woollen one, or sleeves to be turned up and fixed above elbows, or, where possible, ordinary clothing removed and an **operation suit** put on.

3. Thorough preparation of hands, arms, nails, etc., according to methods already described.

4. Sterilised operation gown, cap and mask, and rubber gloves (Figs. 10 and 27) to be put on.

5. Preliminary dressing (if one has been applied) on patient to be removed, and field of operation to be again prepared or washed with an alcoholic solution of mercury biniodide (1 in 500), or by iodine or picric acid method.

6. Hands to be again disinfected if there has been any possible contamination or source of contact with non-sterilised area or substances, and a fresh pair of rubber gloves put on.

7. Sterilised towels and waterproof tissue to be arranged around field of operation and fixed with clips, so as effectively to prevent contact with non-sterilised materials.

8. Special instructions, if any are requisite, to be given to assistant and nurse.

When these preliminary preparations have been carried out, the actual operation may be commenced, the surgeon first assuring himself that the anæsthetist is ready for him to begin.

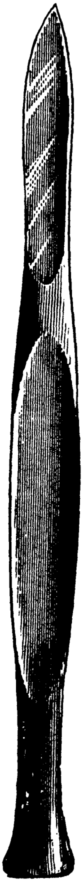

FIG. 50.—Scalpel of good shape, with a metal handle.

Actual operation.—Every surgical operation can be conveniently divided into several stages, the number of which varies somewhat according to the class of operation which is being performed. In nearly all cases the first stage is the *skin incision*. This is made with a cutting instrument, usually a scalpel. In some forms of operation, however, such as tenotomy, a special knife called a tenotome is used; or, in amputations, an amputation knife of suitable shape is employed; whilst in those cases in which the skin is not divided, such as in the removal of a nasal polypus or the excision of laryngeal growths by the intralaryngeal method, no knife is necessary, a special form of instrument suitable for the individual operation being made use of. Fig. 50 is a representation of a good form of scalpel. This form of knife is recommended for making most skin incisions which are of moderate length, and for carrying out any dissections which may be necessary during the further stages of the operation.

Methods of holding a knife.—Several different methods of holding a knife, when performing a surgical operation, are adopted. These may be be classified as follows, namely:—

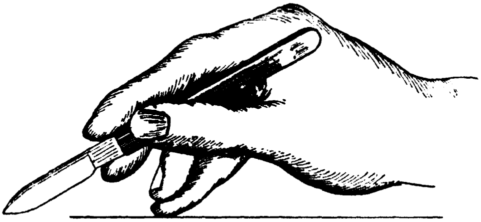

FIG. 51.—" Dissecting " position of holding a knife.

(*a*) " Dissecting " position.
(*b*) " Fiddle-bow " position.
(*c*) " Dinner-knife " position.
(*d*) " Grasping " position.

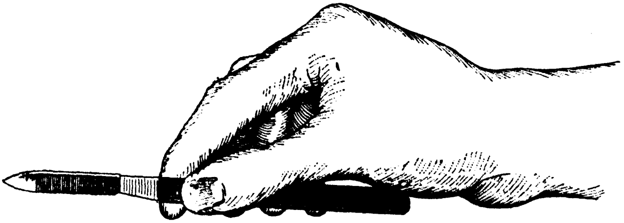

FIG. 52.—" Fiddle-bow " position of holding a knife.

(*a*) Fig. 51 is an illustration of the manner in which a scalpel ought to be held in the first or " dissecting " position. This is sometimes called the " pen " or " writing " position. This method ought to be adopted in making nearly all incisions which are not more than 3 or 4 inches in length, and in all cases where any fine or delicate dissection is necessary, such as the exposure of an artery, nerve, or vein, or when separating any new growth or other pathological formation from its connections with important structures.

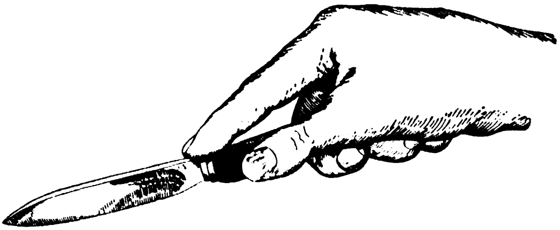

FIG. 53.—" Dinner-knife " method of holding a knife.

(*b*) Fig. 52 is a representation of a scalpel held in the " fiddle-bow " position.

This method of holding a knife is made use of by some surgeons when making skin incisions and rough dissections, but its adoption is not recommended, since the instrument is not held so firmly as in Fig. 51, and consequently greater risk is incurred, in the performance of a delicate dissection, of doing damage to the adjacent structures.

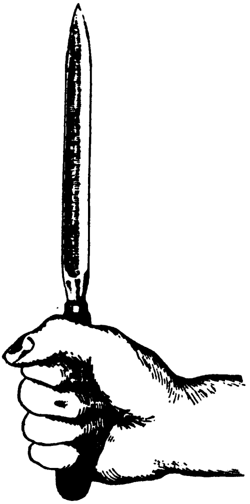

FIG. 54.—Amputation knife held in the "grasping" position.

(*c*) When it is desired to make a long incision, as in the removal of a large tumour or the formation of the flaps in an amputation, or to separate soft tissues from their connection with bone, as in excision of a joint, the knife should be held in the so-called " dinner-knife " position. This method is shown in Fig. 53.

(*d*) When it is necessary for the surgeon to make a long sweeping cut, as in performing an amputation by the " circular " method, the knife is usually held in the position shown in Fig. 54. This position is sometimes called the " grasping " position.

Great care must be taken, when making an incision through the skin and underlying soft tissues, to avoid what is called " tailing " of the incision. By the term " tailing," in operative surgery, is understood making the central part of an incision deeper than either one or both extremities. In order to avoid this, some surgeons advise that the knife should be held in a vertical position at the commencement of the incision, thus making this part of the operation of the nature of a stab. There s a decided objection to this method of commencing an incision. The skin is much tougher and more resistant than the underlying soft tissues, and, owing to this fact, it sometimes happens, when the scalpel is entered in this manner, that the point penetrates much more deeply than is wished, and perforates an important blood vessel, or divides an adjacent nerve trunk. On this account the "vertical" method of commencing an incision is not recommended. It is advised that all ordinary incisions which are of moderate length should be commenced with the knife held as in the position shown in Fig. 53, and that the blade of the instrument should be used for cutting the tissues; as the knife is brought out from the wound, the handle is raised, so as to make it almost vertical, by which means "tailing" in this

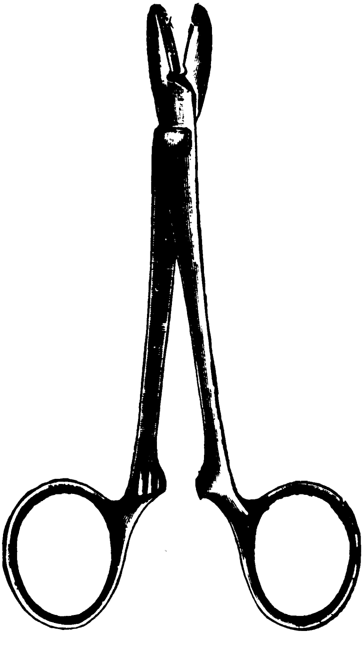

FIG. 55.—Pressure forceps.

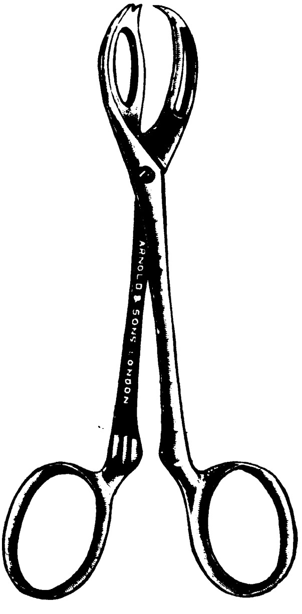

FIG. 56.—Tissue forceps.

part of the wound is avoided. A beginner in operative surgery usually has a tendency to use the point of the knife too much, instead of the blade, whilst making the main part of the incision. The wound is maintained of equal depth for its entire length, until the anatomical structure sought for is laid bare. In order to do this, it is usually necessary to make an occasional additional light stroke with the knife in the upper part of the incision, since there is a tendency slightly to tail this portion of the cut.

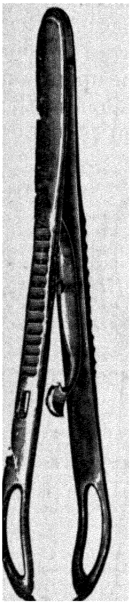
FIG. 57.—Artery forceps.

The further stages of each operation differ according to the procedure which is being carried out. They will be described in connection with the individual operations.

Arrest of hæmorrhage.—During the performance of every surgical operation which necessitates the division of blood vessels, attention must be paid to the arrest of hæmorrhage. This is effected by seizing each bleeding point with a pair of pressure forceps, and then applying a ligature. Figs. 55 and 57 are illustrations of pressure and artery forceps. Hæmorrhage from small blood vessels can usually be arrested by seizing the bleeding point with pressure forceps and twisting it. This is called arrest of hæmorrhage by torsion. Occasionally it is desirable to operate by what is called the "bloodless" method. In this case an elastic rubber bandage is wrapped around the affected limb, commencing below, and applied sufficiently tightly to force the blood upwards, and to arrest the circulation in the arteries which supply the part. An elastic tourniquet is then fastened around the limb above the region upon which it is proposed to operate, a strip of lint being placed between the rubber tube and the skin, and the elastic bandage removed. When the operation is completed this tourniquet is gradually loosened, and all bleeding vessels picked up with pressure or artery forceps and ligatured in the usual manner. Figs. 58, 59,

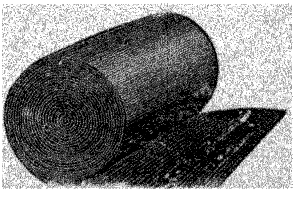
FIG. 58.—Rubber bandage for rendering a limb bloodless during an operation.

and 60 are illustrations of the rubber bandage and tourniquet which are used for this purpose. The use of the bandage may be dispensed with in many cases, and, instead, the limb may be

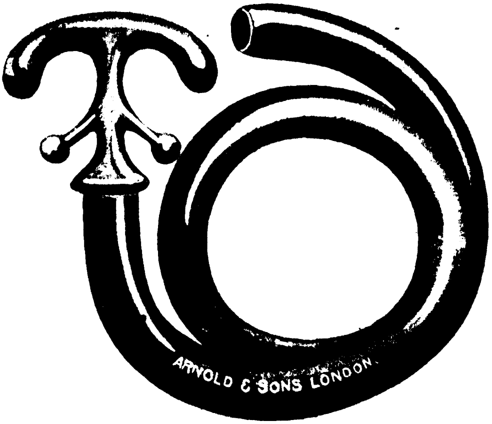

Fig. 59.—Elastic tourniquet.

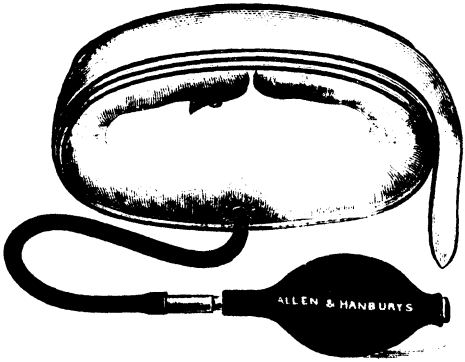

Fig. 60.—Pneumatic tourniquet.

elevated for a few minutes, and the blood forced towards the trunk by stroking with the hands before the application of the tourniquet. All hæmorrhage should be carefully arrested before a wound is closed.

Closure of wound.—The final stage of the majority of surgical operations is the closure of the external wound. This is usually effected by the introduction of some form of suture or sutures. The two commonest and most useful methods are the "interrupted" and the "continuous" suture. The instruments which are necessary for this proceeding are needles, a needle-holder, and suture material. Figs. 61, 62, and 63 are illustrations of fully curved, half-curved, and straight surgical needles. The shape of the needle which ought to be used for closing an incision depends upon the depth and accessibility of the wound. In deep wounds, or wounds which are not readily accessible, curved needles will be found to be most useful, whilst for shallow cuts straight needles will be most convenient. Fig. 64 represents a useful and simple form of needle-holder. The instrument shown in Fig. 65 will occasionally be found to be very useful in sewing up external wounds. The needle is passed through the tissues, the suture slipped into the slot near the apex, and the needle withdrawn. The use of this form of needle obviates the necessity of threading each suture, and also the use of a

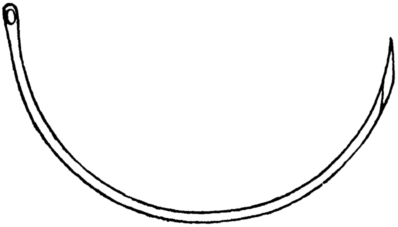

FIG. 61.—Fully curved needle.

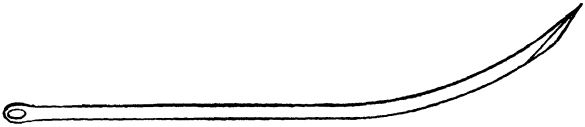

FIG. 62.—Half-curved needle

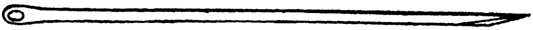

FIG 63.—Straight needle.

needle-holder. It will be found most useful for closing long incisions.

Closure of an incision by a simple interrupted suture.—The individual sutures are introduced separately at equal distances from each other, and after the manner shown in Fig. 66. The insertion of a series of interrupted sutures can be facilitated by the assistant placing a blunt hook in each extremity of the wound, and exerting traction in opposite directions so as to render the margins taut.

When all the sutures have been inserted, each one is tied and the ends cut short. Fig. 67 shows the appearance of an incision which has been closed by the insertion of a row of simple "interrupted" sutures. This method, in my opinion, is the best for the closure of the wounds. When the wound is a deep one it is advisable to close the deeper parts by the insertion of tiers of "buried" sutures.

Closure of an incision by a continuous suture.—This form of closure of a skin incision is a good one, since by its adoption the margins of the wound can be readily brought into fair apposition and kept there until union has taken place. A little more care, however, is required than when the "interrupted" suture is inserted. Fig. 68 shows the method of inserting a continuous suture, and Fig. 69 its appearance when the margins of the incision have been approximated and the ends secured.

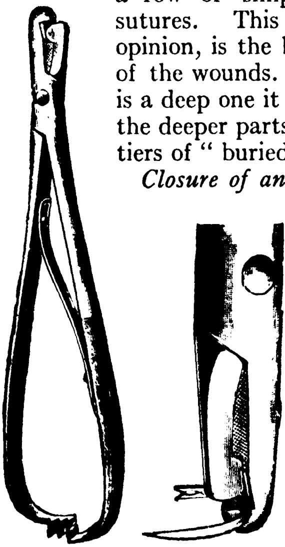

Fig. 64.—Needle-holder suitable for all kinds of surgical needles. Richter.

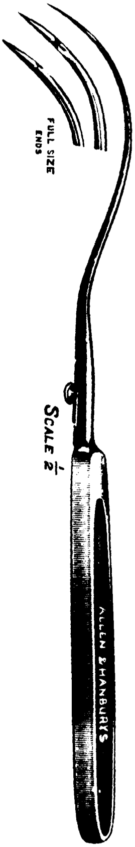

Fig. 65.—Reverdin's needle and holder.

The disadvantage of the continuous suture is, that if one part of the line of suture " cuts out," the approximation of the margins of the entire wound is imperilled.

When a series of sutures has been inserted for the closure of an external wound, each one should be tied separately by making a " reef " knot. Care must be taken not to tie what is called a " granny " knot, as it is liable to slip, and hence to allow margins of the cut to become slightly separated. Fig. 70 shows the method of tying a " reef " knot, and Fig. 71 a " granny " knot. When silk-worm gut is used for closing an external wound, the best method of tying it is by the first stage of a so-called true surgical knot. Fig. 72 is an illustration of this method of tying a suture, whilst Fig. 73 shows the completed

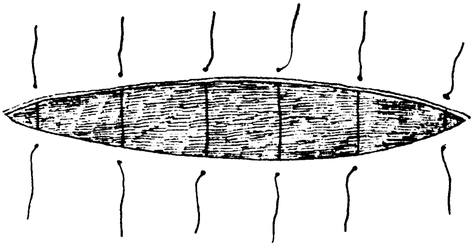

FIG. 66.—Method of introduction of a series of simple " interrupted " sutures. All the sutures have been introduced, but none tied.

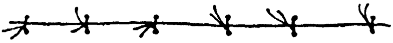

FIG. 67.—Row of simple " interrupted " sutures inserted, tied, and ends cut short.

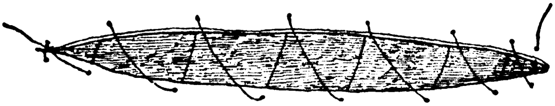

FIG. 68.—Method of inserting a simple " continuous " suture.

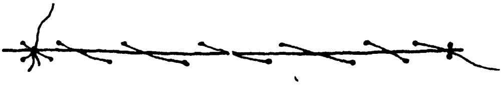

FIG. 69.—Appearance of an incision when closed by a " continuous " suture.

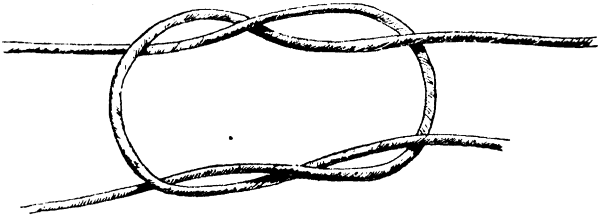

FIG. 70.—Method of tying a "reef" knot.

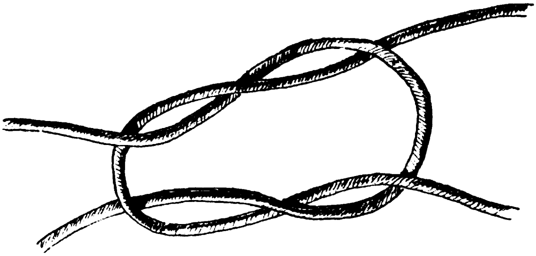

FIG. 71.—A "granny" knot.

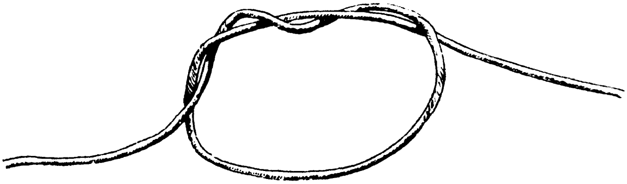

FIG. 72.—True "surgical" knot, first stage.

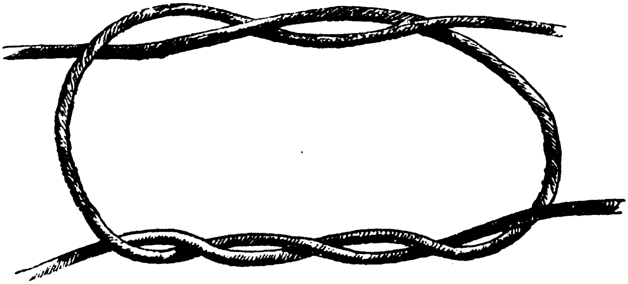

FIG. 73.—True "surgical" knot, completed.

knot. This method of tying sutures will also be found to be very useful in those cases in which it is somewhat difficult to keep the margins of the incision in exact apposition during the making of the second " hitch."

Fig. 74 is a representation of a wound closed by a series of " interrupted " sutures of silk-worm gut, each suture being secured by the double " hitch " of the surgical knot.

When a suture is tied, care should be taken not to pull it too tightly, otherwise the suture may cut out, or an unnecessary amount of scarring result. Each suture should be tied only tight enough to keep the margins of the wound in exact apposition. When the incision is a deep one, or the cut surfaces are very extensive, the above methods of closing a wound are insufficient, since the deeper parts of the cut are not brought together by the sutures. In order to avoid non-approximation of the deeper parts of an incision, " buried " sutures are sometimes inserted. This method is of much use in closing wounds of the abdominal wall ; but in the extremities, as after amputations or the removal of tumours, the cut surfaces can in nearly all cases be brought into exact apposition by the careful application of bandages.

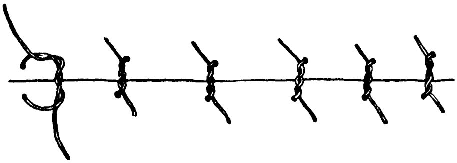

FIG. 74.—A wound closed by " interrupted " sutures, each being secured by the " double hitch " of the true " surgical " knot.

Introduction of drainage tubes.—A drainage tube is rarely required in the treatment of a wound which has been made by a surgical operation. In all cases of clean incised wounds, where the cut surfaces can be brought into apposition by the insertion of sutures and the application of a dressing and bandages, no drainage is necessary. When, however, extensive cut surfaces have been made, such as in removal of the breast for carcinoma, or in amputations, and there has been much oozing of blood, or the tissues were œdematous at the time of operation, it is advisable to leave either an angle or a portion of the wound unclosed, and not to apply the sutures in the rest of the incision too closely or too tightly. This precaution will allow of the necessary escape of blood and lymph from the depths of the wound, and its absorption by the overlying dressing. It occasionally happens that it is not possible to effect complete approximation of the deeper portions of a wound—as after the extirpation of a large tumour with deep connections, or after the removal of abdominal or pelvic tumours which had extensive connections or adhesions. In these cases it is advisable either to put in a drainage tube, or to pack that portion of the cavity whose walls cannot be approximated with a long strip or tampon of aseptic gauze, one extremity of which is allowed to protrude from an angle of the external wound, which is left open for the purpose. Usually this method of packing with gauze will be found more efficacious than the use of a drainage tube. Often it will be found very useful to employ a rubber drainage tube with a strip of gauze passed down the interior to the bottom of the cavity or space it is desired to drain. In both cases the strip of gauze or the drainage tube is removed at the end of twenty-four or at most forty-eight hours, unless some complication such as hæmorrhage or suppuration has occurred.

A drainage tube or a tampon of gauze ought to be placed in those wounds which are the seat of septic processes at the time of operation, and also in cases in which a fistula is very liable to result, as after certain operations on the alimentary canal and the urinary system.

Application of dressings.—When the suturing of an operation wound has been completed, the entire field of operation should be sponged dry, and then dry sterilised dressings of gauze (which may or may not be impregnated with chemical antiseptics) carefully applied and fixed in position by firm and even bandaging. Painting the course of the incision with tincture of iodine (2½ per cent.) before the application of the dressings is strongly advised; since it helps considerably in the avoidance of superficial suppuration from skin infection. If there is any possibility of contamination of the dressings from without—such as by soaking with urine—a layer of impervious material should be placed outside the gauze dressings and bandages.

After-treatment.—The treatment which ought to be adopted after the performance of a surgical operation can be considered from two aspects, namely—(*a*) the after-treatment of the wound, and (*b*) the after-treatment of the patient generally.

(*a*) *The after-treatment of the wound.*—When the wound is of an aseptic nature, and no drainage tubes or tampons of gauze are inserted, the dressings which have been applied at the end of the operation can be left on for seven or eight days, and then removed and replaced by others. If, however, much oozing occurs, and the dressings become soaked with exudations, they ought to be removed and replaced by fresh ones earlier. The sutures which have been inserted for the closure of the external wound should be removed at the end of five or seven days, especially if they are of silk. If silk sutures are left longer than this they are very liable to assist in the development of " sutural " or " stitch " abscesses. When silk-worm gut is used it can be left longer—ten days or a fortnight—without an abscess of this nature being formed. When drainage tubes or tampons of gauze are inserted in an operation wound they should be removed at the end of twenty-four hours, and replaced by others if it is considered necessary.

(*b*) *The general after-treatment.*—Careful attention must be paid to the feeding of the patient, and also to the hygienic conditions and surroundings. The part of the body which has been the seat of operation should be kept at rest, either by simply keeping the patient in bed, or by applying some form of splint or stiff apparatus. The air should be allowed to circulate freely in the neighbourhood of the dressings, so as to prevent the atmosphere becoming moist, foul, and contaminated with the exhalations from the skin. This can be effected by raising the bed-clothes from the affected portion by means of a cradle.

CHAPTER IV

OPERATIONS UPON THE STOMACH AND INTESTINES

THE majority of operations upon the stomach and intestines are carried out through an incision in the anterior abdominal wall. In lumbar colotomy, however, the incision is made in the loin; and in operations upon the rectum the posterior half of the perineum or the region of the sacrum is the usual seat of the incision.

Hence the *first stage*, in most operations upon the stomach or intestines, is the making of an incision through the abdominal parietes, and the opening of the peritoneal cavity. This incision is often made in the middle line through the linea alba, so as to avoid the division of nerves. It is better, however, to make the incision a little to one or other side of the middle line, and, after division of the skin, subcutaneous fascia, and anterior layer of the sheath of the rectus abdominis muscle, to define the inner margin of this muscle and retract it outwards, and then divide the posterior layer of the rectus sheath and the parietal peritoneum in the same line as the original incision. This method of incising the abdominal wall tends to

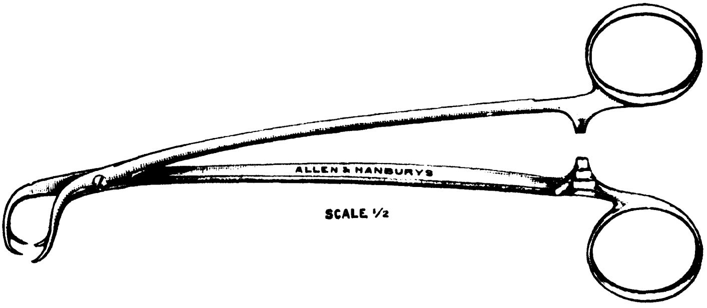

FIG. 75.—Towel-holding forceps.

minimise the risk of occurrence of a ventral hernia at a later period. If it is not possible or convenient to make the incision, either on one side of the middle line or in the middle line, it should be so placed that the nerves which supply the muscles of the anterior abdominal wall are exposed to as little injury as possible. These nerves run for the most part in an oblique direction from behind downwards and forwards. The large blood vessels of the anterior abdominal wall—the inferior epigastric (deep epigastric) artery which runs from opposite the mid-point between the anterior superior spine and the symphysis pubis to within a short distance of the umbilicus, and the superior epigastric artery which runs from the seventh costal cartilage to the umbilicus — should also be avoided.

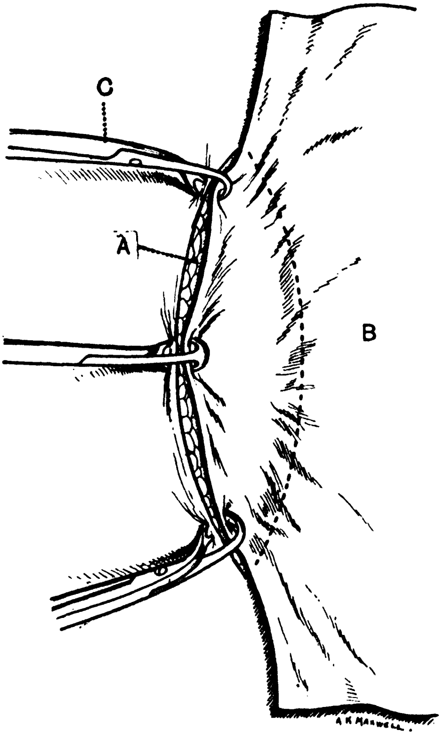

FIG. 75A.—Method of fixation of towel or rubber sheeting to margin of a recent wound.

A. Margin of wound.
B. Towel or rubber sheet.
C. Towel-holding forceps.

The length of the parietal incision varies according to the nature of the operation. The longer the incision the greater is the liability to a subsequent ventral hernia. It is, however, most important that the surgeon should have an unobstructed view of the organs upon which he proposes to operate, and sufficient room for the easy performance of the necessary manipulative procedures.

When the skin, fasciæ, and muscular strata of the abdominal wall have been divided, or separated and retracted, all hæmorrhage should be arrested by the application of ligatures to the bleeding points, and the wound sponged dry. Next, the peritoneal cavity is opened. The parietal peritoneum can usually be recognised by the loose fatty tissue layer—extra-peritoneal fat—which lies between its external aspect and the transversalis fascia, and also by the arborescent arrangement of the blood vessels upon its surface. The peritoneal cavity is most safely

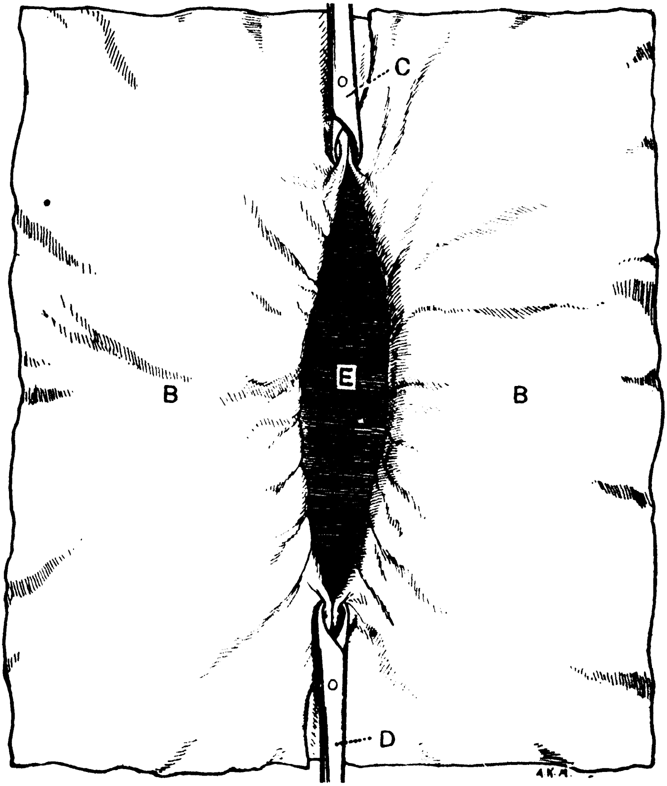

FIG. 75B. —Margins of recent wound protected by towel or rubber sheeting.

B. Towel or rubber sheeting.
C. Towel-holding forceps at upper angle of wound.
D. Towel-holding forceps at lower angle of wound.
E. Field of operation.

opened by picking up a piece of the membrane with dissecting forceps, and cutting upon the points with the scalpel. When this has been done the aperture is enlarged by pushing through it the points of a pair of dissecting forceps, and cutting between them. The fingers of the left hand may then be introduced, and the opening further enlarged by cutting between the fingers, which serve as a director and keep the intestine and omentum out of the way. When a piece of the parietal peritoneum is picked up with the dissecting forceps the underlying intestine or omentum slips away, if the normal peritoneal cavity has not been obliterated by peritonitis and the formation of adhesions. The margins of the abdominal wound should be protected by sterilised cloths or rubber sheeting temporarily fixed to the margins by towel-holding forceps (Figs. 75, 75A, and 75B).

The *second stage* of an abdominal operation of this kind is the finding of the anatomical structure upon which it is proposed to operate, and the performance of whatever procedure is necessary.

When the object of the operation has been effected, such as the resection of a portion of the alimentary canal or the establishment of an intestinal anastomosis, the parietal wound is closed; whilst in others, such as the creation of an artificial anus or the drainage of a purulent collection, it is left open so as to allow the insertion of a drainage tube or packing with strips of gauze.

Washing out, or irrigation of the peritoneal cavity.—Before the closure of the wound in the parietes, care must be taken to remove by sponging or "local" irrigation all traces of blood or any kind of extraneous matter from the peritoneal cavity. In all cases where the peritoneum has been soiled by septic material from the alimentary canal, or by pus, it is advisable thoroughly to sponge or irrigate the contaminated area with warm sterilised salt solution (0·75 per cent.).

Methods of intestinal suture.—For the performance of operations upon the stomach and intestines, it is necessary for the surgeon to be familiar with some of the methods of intestinal suture. The principle of these will now be described. The most important of these are—

(*a*) Simple continuous suture.
(*b*) Simple interrupted suture.
(*c*) Lembert's suture.
(*d*) Czerny's suture (Czerny-Lembert).
(*e*) Gussenbauer's suture.
(*f*) The Czerny-Lembert-Wölfler suture.
(*g*) Chaput's suture.
(*h*) Halsted's mattress or quilted suture.

(*a*) and (*b*) *The simple continuous and simple interrupted sutures* have already been described on page 60, etc.

(*c*) *Lembert's suture.*—Fig. 76 shows the mode of inserting a suture by Lembert's method, and Fig. 77 the manner in which the serous surfaces are brought together.

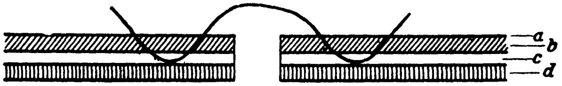

FIG. 76.—Diagrammatic section of a portion of gut wall, showing the method of insertion of a Lembert's suture.

It should be specially noted that in this and in the following figures this suture passes through the submucous tissue.

a. Peritoneum.
b. Muscular coat.
c. Submucous coat.
d. Mucous coat.

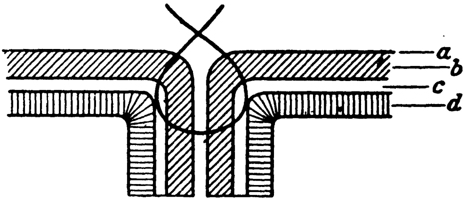

FIG. 77.—Diagrammatic section of a portion of intestinal wall, showing method of approximation by Lembert's suture.

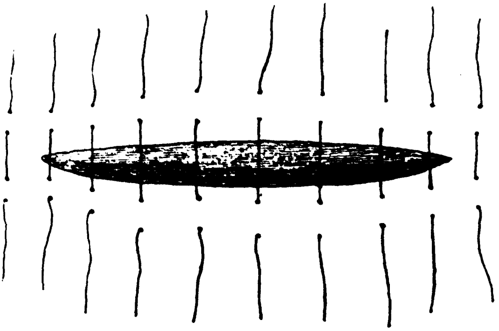

FIG. 78.—Illustration of an incision, with a series of Lembert's sutures inserted but not tied.

Fig. 78 is an illustration of an incision for the closure of which a series of Lembert's sutures has been inserted.

Fig. 79 shows the appearance of such an incision when the sutures have been tied and the ends cut short.

In inserting a Lembert's suture the needle is made to transfix the serous and muscular coats, and penetrate the submucous coat of the intestine on one side of the wound, and then the same proceeding is repeated on the other side, care being taken not to pierce the mucous coat.

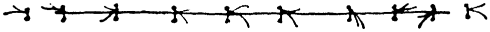

FIG. 79.—The same incision, with the sutures tied and the ends cut short.

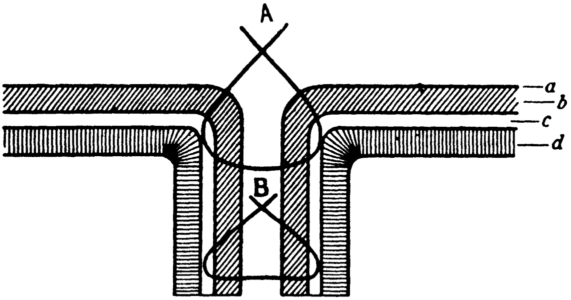

FIG. 80.—Czerny's suture. Diagrammatic representation of method of inserting Czerny's suture.

A. First suture. | B. Second suture.

a. Serous coat. | c. Submucous membrane.
b. Muscular coat. | d. Mucous membrane.

(*d*) *Czerny's suture* really consists of two superimposed tiers of Lembert's sutures; the first tier unites the serous and muscular coats of the margins of the wound, whilst the second is placed a short distance beyond. All the sutures of the first tier are inserted, tied, and cut short before any of the second tier are passed.

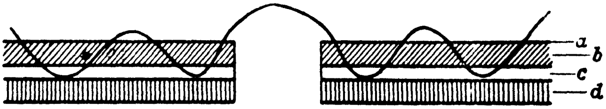

FIG. 81.—Gussenbauer's suture. Section of gut wall, showing method of insertion.

a. Serous coat. | c. Submucous membrane.
b. Muscular coat. | d. Mucous membrane.

Fig. 80 shows the method of inserting this variety of suture.

(*e*) *The suture of Gussenbauer* is in reality a double Lembert (or Czerny) suture, inserted with one thread at the same time (Figs. 81 and 82).

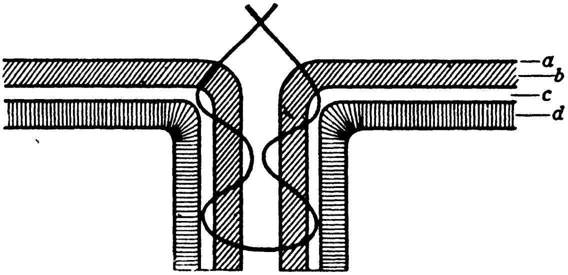

FIG. 82.—Gussenbauer's suture. Section of gut wall, showing manner of approximation as suture is tied.

a. Serous coat.	*c*. Submucous membrane.
b. Muscular coat.	*d*. Mucous membrane.

(*f*) *The Czerny-Lembert-Wölfler suture, or suture in three stages.*—This method of suture is essentially a Czerny's suture with the addition of a tier of sutures which unite mucous membrane to mucous membrane, as shown in Fig. 82.

(*g*) *Chaput's suture.*—The essential point in this suture is the preliminary separation for a short distance of the mucous membrane from the muscular and serous coats. When this has been done the margins of the mucous membrane are united by the insertion of a series of simple interrupted sutures. Next, the serous and muscular coats are slightly everted and fixed in

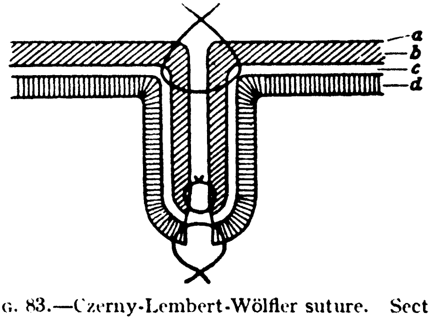

FIG. 83.—Czerny-Lembert-Wölfler suture. Section of intestine, showing manner of insertion, etc., of the three tiers of sutures.

a. Serous coat.	*c*. Submucous membrane.
b. Muscular coat.	*d*. Mucous membrane.

apposition by a series of simple interrupted sutures, according to the method shown in Fig. 84.

(*h*) *Halsted's quilted or mattress suture* is inserted according to the method shown in Fig. 85, care being taken to ensure that the needle passes through the muscular coat and pierces part of the submucous layer.

Of these methods of intestinal suture the best is probably a combination of a continuous suture interrupted in several places for the mucous and submucous layers, and a Lembert's or Halsted's suture for the remainder.

This method of closure of intestinal wounds produces less puckering of the tissues, and hence causes the minimum amount of contraction.

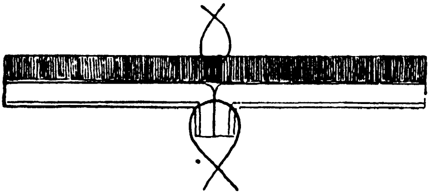

Fig. 84.—Chaput's suture. Section of intestines, showing method of insertion and manner of approximation.

Method of closure of the parietal wound.—The incision through the abdominal wall may be closed in the following ways:

1. By one row of simple interrupted sutures, each suture passing through all the layers of the abdominal wall.

2. By two tiers of sutures—one being a simple interrupted suture for the peritoneum, and the other a row of simple interrupted sutures which pass through the rest of the abdominal wall.

3. By three tiers of sutures—the first, a simple interrupted suture through the peritoneum; the second, a series of buried interrupted sutures, which approximates the muscular strata; and the third, interrupted or continuous for the fasciæ and skin. The best of these three methods, in the majority of instances, is that by three tiers of sutures.

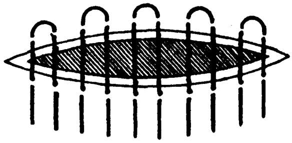

Fig. 85.—Halsted's quilted suture. Appearance of a wound with a series of these sutures inserted.

When more than one tier of sutures is inserted, the deep ones are tied and the ends cut short before the next row is inserted.

Enumeration of instruments and sponges.—Before commencing an abdominal operation all instruments, sponges, and pads should be counted and entered on an "operation list." At the termination of the operation they are again counted and their number compared with the list. This precaution will ensure that instruments or sponges are not left behind within the abdomen.

Position of patient.—When operations upon the abdominal viscera are about to be performed, in the majority of instances the most suitable and convenient position is to have the patient

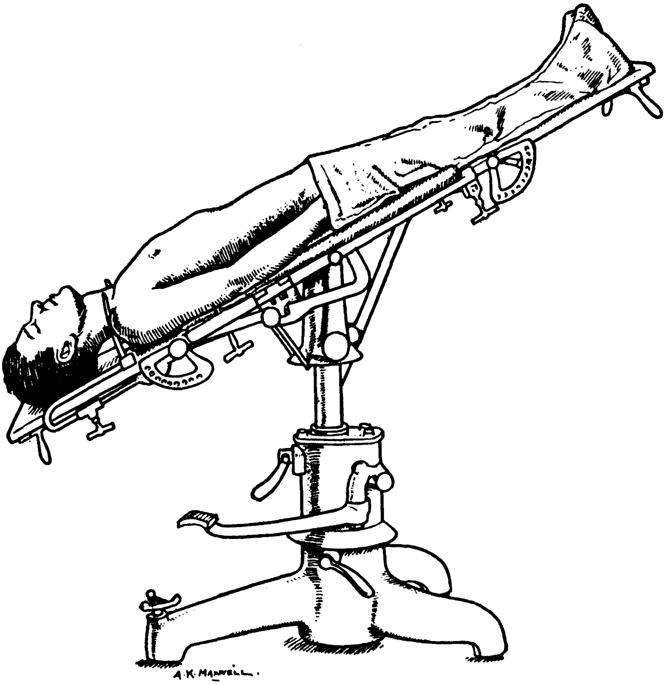

FIG. 86.—Operation table. Patient in "raised pelvic" or "Trendelenburg" position.

lying in the dorsal decubitus, with the knees slightly drawn up or raised. When, however, it is necessary to deal with the pelvic viscera, or with conditions of the intrapelvic portions of the intestines, considerable aid in manipulation and ready exposure of the parts to be operated upon may be obtained by raising the pelvis, or placing the patient in what is generally known as the "raised pelvic" or "Trendelenburg" position. Fig. 86 is an illustration of a patient placed in this position. The advantages of this position are that the intestines tend to fall upwards into the upper portion of the abdominal cavity, and so do not interfere with the operator's free view of the pelvic cavity and its contents, whilst the pelvic viscera or any tumour within the pelvis fall forwards and upwards, and can be brought more readily into a wound in the abdominal parietes. When the pelvis is the seat of a localised peritonitis, or a collection of purulent matter in connection with one of its viscera, very great care must be taken, when this position is made use of, completely to shut off the upper portion of the abdominal cavity with sponges or pads, and so prevent the escape of purulent matter upwards, and consequent direct contamination and infection of the peritoneum.

In the majority of instances, when cases of intrapelvic suppuration are being dealt with, I think it is inadvisable to place the patient in the "raised pelvic" or "Trendelenburg" position, owing to the risk of contamination of the upper portions of the peritoneal cavity with septic material from the pelvis by gravitation (Fig. 86).

The following operations upon the stomach and intestines will now be described :—

Operations upon the Stomach

Gastrostomy.
Gastrotomy.
Gastrectomy.
Pyloroplasty (Finney's operation).
Pylorectomy.
Rammstedt's operation.
Gastro-enterostomy—
    Posterior operation.
    Anterior operation.
Operation for perforated gastric ulcer.

Operations upon the Small Intestine

Closure of perforating wound of the intestine.
Resection of the intestine—
    1. End-to-end anastomosis.
    2. Lateral anastomosis.
Formation of artificial anus.
Operations for perforation of duodenal and typhoid ulcers.

Operations upon the Large Intestine

Removal of vermiform process (appendix).
Operation for suppurative appendicitis.
Appendicostomy.
Excision of cæcum.
Intussusception.
Resection of large intestine.
Colostomy—
    Inguinal.

OPERATIONS UPON THE RECTUM

For hæmorrhoids.
For fistula in ano.
Excision of rectum—
  1. Perineal method.
  2. Abdominal method.
  3. Abdomino-perineal method
  4. Vaginal method.
Operation for imperforate rectum and anus.
Operation for prolapse of rectum.

OPERATIONS UPON THE STOMACH

Gastrostomy.—The operation of gastrostomy has for its object the establishment of a permanent fistulous communication between the cavity of the stomach and the surface of the body.

The stomach is situated in the upper part and on the left side of the abdomen, but its exact extent and relations depend upon the amount of its distension. In every condition, however, the main part of the viscus occupies the left hypochondrium and the left half of the epigastrium.

Indications.—The indications for the performance of gastrostomy may be said to be—

(*a*) Fibrous stricture of the œsophagus, which cannot be dilated.

(*b*) Carcinoma of the œsophagus, which is beginning to cause obstruction to the passage of food. When the carcinomatous growth is situated in the cervical portion of the œsophagus, and diagnosis is made early, it may be advisable to resect the involved portion of the canal. Up to the present, however, operations of this kind have not met with much permanent success.

(*c*) Carcinoma of the cardiac orifice of the stomach, causing obstruction to the passage of food.

Before deciding to recommend the operation in cases of carcinoma very careful consideration must be given to the general condition of the patient, to the extent of emaciation which has occurred, and to the possibility of the occurrence of secondary growths or of extension of the malignant process to one of the surrounding or adjacent anatomical structures, such as the larynx, trachea, bronchus, pericardium, or pleura. When the disease is in an advanced stage, and the patient has begun to show signs of cancerous cachexia, or when there are signs of extension to any part of the respiratory system, an operation ought not to be recommended. When an operation is performed at this stage no material advantage is gained; and in the majority of instances the patient dies as the direct result of the operative procedure, the tissues not having sufficient vitality to repair the injuries made by the scalpel. The operation, if it is to be performed at all, must be done in the early stages of the disease. Then a patient's life can undoubtedly be prolonged, and his condition made much more comfortable. It should be borne in mind, however, when discussing the advisability of performing this operation, that when the patient has recovered from the operation he usually requires careful attention and assistance in feeding. Hence medical or nursing assistance is usually requisite until the end of his days. Therefore, as regards this operation, poor or hospital patients are at a disadvantage when compared with the wealthy. Intelligent patients may be taught how to feed and look after themselves, but often in the case of a poor patient the condition after the operation, when he has returned to his home, is as bad or worse than it was before anything was done.

Special instruments.—Rubber tube or gum elastic catheter, sewing needles.

Position.—The patient is placed in the dorsal position, near the left side of the table. The operator stands on the left side, and the chief assistant on the other side directly opposite to him.

Varieties of operation.—Many varieties of gastrostomy have been described and practised. Those which I consider most useful are—

(*a*) " Internal Cone " or Senn's operation.

(*b*) " External Cone " passing obliquely through anterior abdominal wall; known as Frank's or Albert's operation.

(*c*) " External Cone " or simple gastric fistula.

As the outcome of an extended experience of the after results of these operations, I feel very strongly that the " Internal Cone " or Senn's operation is far the best. It gives the best functional results, there is less liability of leakage of stomach contents, and the shock due to the operation is slight, whilst the entire procedure is completed at one sitting. On this account I recommend its general adoption when gastrostomy is considered advisable.

The three forms of operation will now be described in detail.

Gastrostomy ("Internal Cone" operation or Senn's method).—The essential characteristic of this method is the inversion of a cone of the anterior wall of the stomach towards the lumen of the viscus, in order to produce a fold of the stomach wall which shall act as a valve in preventing escape of the stomach contents along the artificially created fistulous opening and track.

Operation.—(*a*) *Parietal incision, finding of stomach and bringing it into the parietal wound.*—An incision, 2 to 3 inches long, according to the obesity of the patient, is made, which commences immediately below the left costal margin at the junction of the eighth and ninth costal cartilages, and extends vertically downwards. The skin, subcutaneous fascia, and anterior layer of the sheath of the rectus abdominis muscle are first incised, and the vertical fibres of the rectus muscle exposed. These are readily recognised by their fleshy appearance and their vertical direction. When this has been done a probe-pointed steel director is taken, and the fibres of the muscle separated for the entire length of the incision. The separation of the fibres should be at least ½ inch from the left lateral margin of the muscle; and if the incision happens to have been made too far to the left the inner margin of the wound should be retracted inwards, so as to allow of this being done. When this separation has been satisfactorily effected, the posterior layer of the sheath of the rectus muscle and the extra-peritoneal fat and peritoneum are divided in the line of the original incision. The peritoneal cavity is thus opened. The stomach is sought for by passing the fingers upwards and towards the left. It is readily recognized by the smoothness and thickness of its wall, its reddish-pink colour, and by having omentum attached to both its upper and lower borders (the hepato-gastric ligament (small omentum) is attached to the small curvature and the great omentum to the great curvature). When any difficulty is experienced in finding the stomach, the forefinger and thumb of the left hand should be passed upwards in the wound until the lower surface of the left lobe of the liver can be felt. Then this surface is traced backwards to the attachment of the hepato-gastric ligament (small omentum) when, by following the anterior surface of this omentum downwards, the anterior (or superior) aspect of the stomach will always be found. When the stomach has been recognised it is brought into the parietal wound, and an area selected for fixation to

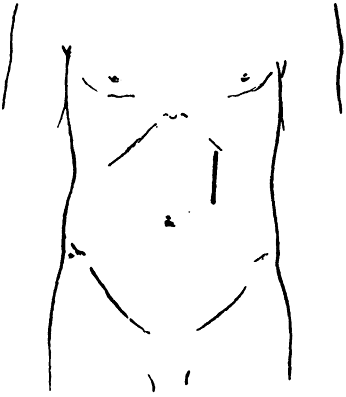

FIG. 87.—Gastrostomy. Parietal Incision.

the abdominal wall. This area should be in the cardiac portion of the viscus, and some distance above the greater curvature.

(*b*) *Incision of stomach wall in centre of selected area, introduction and fixation of red rubber tube, infolding of stomach wall, and fixation of base of cone to parietes.*—The anterior wall of the stomach, being exposed and brought into the parietal wound and an area selected towards the cardiac extremity, a small incision is made through the anterior wall, sufficiently large to admit a No. 12 E. red rubber catheter. A purse-string suture of No. 1 chromicised catgut is introduced around the opening, passing through all the layers of the stomach wall and also picking up the red rubber catheter at one point. This is tied

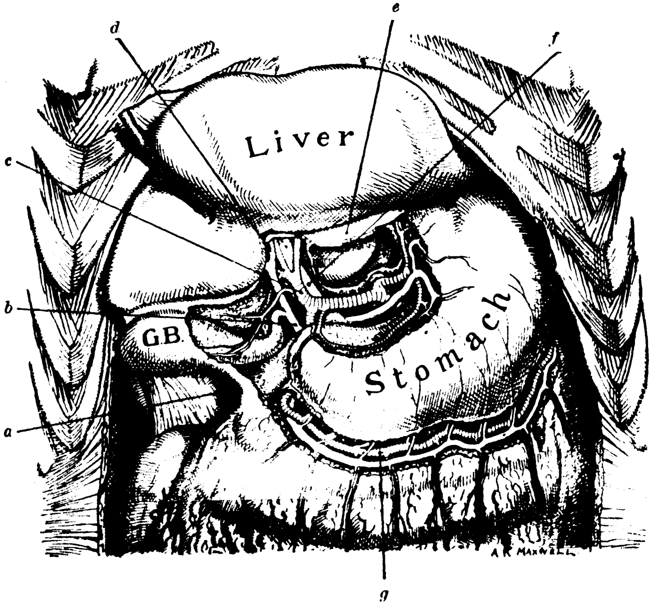

FIG. 88.—To show the stomach and its relations as seen from the front when the left lobe of the liver has been lifted up.

a. Foramen ovale (Winslow).
b. Common bile duct.
c. Hepatic artery.
d. Hepatic duct.
e. Cut margin of gastro-hepatic (small) omentum.
f. Portal vein.
g. Gastro-epiploic artery.
G.B. Gall-bladder.

sufficiently tightly, closely to approximate the margin of the opening in the stomach to the walls of the rubber tube, but not so tightly as to diminish the lumen of the latter. When this has been done the stomach wall is pushed inwards so as to form a cone, the apex of which is the opening containing the rubber tube. A purse-string suture of chromicised catgut is now introduced about ½ inch from the margins of the opening, the serous, muscular, and submucous coats being included. The tube is pushed inwards and the suture tied around the tube. A third suture is then introduced in a similar manner, the stomach wall being farther inverted as before. The portion of the stomach wall at the base of the inverted cone is next fixed to the peritoneal aspect of the parietal wall by the insertion of several interrupted sutures of chromicised gut, each suture taking up the posterior sheath of the rectus and peritoneum of the abdominal wall, and

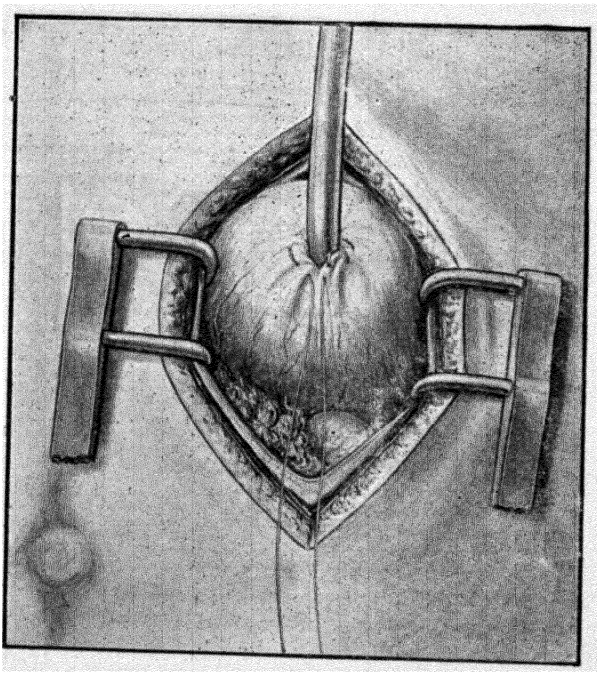

FIG. 89.—Gastrostomy. "Internal Cone" operation. Stomach exposed and red rubber tube fixed by "purse-string suture."

the serous, muscular, and submucous layers of the stomach wall. The upper and lower margins of the incision in the abdominal wall are finally approximated by the insertion of a few sutures of salmon gut.

A rubber tube is attached to the red rubber catheter fixed in the abdominal wall, and dressings are applied. Through this tube the patient can be fed.

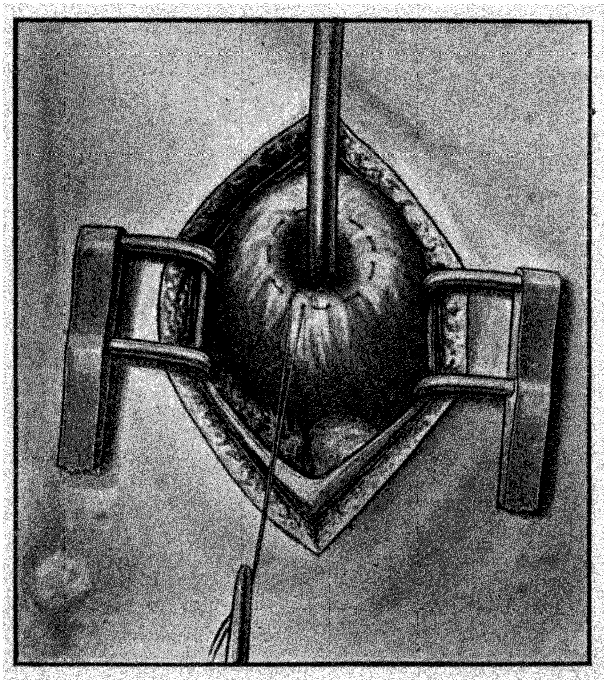

FIG. 90.—Gastrostomy. " Internal Cone " operation. Anterior wall of stomach folded inwards in form of a cone, and purse-string suture inserted but not tied.

At the end of about ten to fourteen days the catheter will become detached, and can be removed and replaced by a slightly larger one.

" **External Cone operation** " (Stomach passing obliquely through abdominal wall, or Frank's operation).—The operation may be divided into three stages, namely—

(*a*) *Incision of the abdominal wall.*—An incision from 2 to

2½ inches in length is made in the abdominal wall parallel to and 1 inch below the left costal margin, and opposite the cartilages of the seventh, eighth, and ninth ribs (Fig. 91 *A a*), or a vertical incision similar to the one adopted in the previous operation may be employed. The scalpel is made to divide the skin, fasciæ, and anterior layer of the sheath of the rectus abdominis muscle; and when the surface of the muscle is exposed, its fibres are separated in a vertical direction for about 1 inch, the separation being about one finger's-breadth from the linea semilunaris. By this means the posterior wall of the sheath is exposed. This is now divided in the line of the original incision, together with the underlying transversalis fascia, extraperitoneal fat, and peritoneum, the margins of the wound in the rectus being retracted.

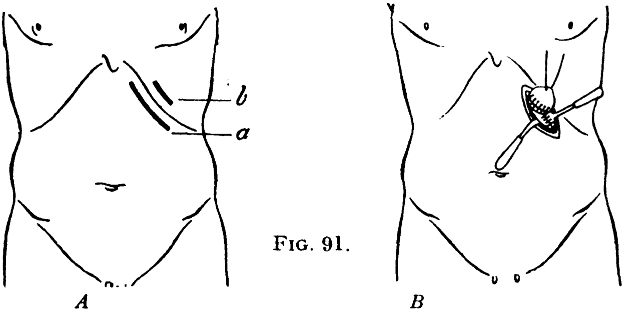

FIG. 91.

Gastrostomy (Frank's or Albert's method). *A*.—Position of incisions.

(*a*) First or abdominal incision.
(*b*) Second or thoracic incision.

B.—Cone of stomach brought out of first incision and sutured to serous and muscular strata of abdominal wall.

(*b*) *Exposure of the stomach and fixation of a portion of the viscus in abdominal wound.*—The stomach is sought for by passing the fingers of the right hand into the peritoneal cavity. It can be recognised by the thickness of its walls, the attachment of its superior margin to the liver by means of the hepato-gastric ligament (small omentum) the smoothness of its surface, and the absence of sacculations and appendices epiploicæ. When the stomach has been recognised a portion of it is brought into the wound, and a point selected upon its anterior aspect opposite to the parietal incision and about 1½ or 2 inches above the great curvature. A thick suture is passed through the serous and muscular coats of the organ at the point selected, and this is left long and used to lift up the stomach during the later stages of the operation. A cone of the anterior wall of the stomach (Fig. 91) is lifted up into the abdominal wound, and its base sutured to the margins of the incision by the insertion of a ring of fine silk or celloidin thread sutures. Each suture passes through the serous, muscular, and submucous portions of the wall of the stomach, and also through the serous and muscular strata of the anterior abdominal wall, the muscular fibres of the rectus abdominis being avoided. These sutures are inserted at intervals of about one-third of an inch, and are all introduced before any are tied. The cone of the stomach which is brought out in this manner is in most cases about 1½ inches in length, but this depends upon the thickness of the anterior abdominal wall. If the abdominal incision is larger than the portion of stomach selected, the ends of the incision are closed by the insertion of sutures in the usual manner.

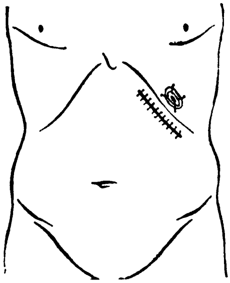

FIG. 92.—Gastrostomy (Frank's or Albert's method). Operation completed. The opening in the stomach is attached to the upper incision.

(*c*) *Incision of the thoracic wall immediately above the costal margin, suture of the stomach to the margins of this opening, and formation of a gastric fistula.*—An incision ¾ inch in length is now made over the costal margin, opposite the middle of the first incision and parallel to it. This is deepened until the deep fascia has been divided and the surface of the external oblique exposed (Fig. 91, *B b*). The bridge of skin and fascia which separates the two incisions is lifted after the deep fascia has been detached from the muscle. The long loop of silk which is fixed to the stomach is passed underneath this bridge of skin, and brought out through the second incision, and traction exerted upon it. The cone of the stomach is thus drawn underneath the cutaneous bridge.

A small aperture, about ½ inch in length, is then made in the wall of the apex of the cone, and the margins of this incision are fixed to those of the wound in the skin by the insertion of sutures. Each suture passes through the skin and fascia, and then through the entire thickness of the wall of the stomach (Fig. 92). The margins of the first incision are then united by interrupted sutures of salmon gut.

The advantages claimed for this operation are: the stomach can be opened at the time of operation, the margins of the aperture and the walls of the fistula can be held in apposition during the intervals between feeding, regurgitation of food is prevented, and peritonitis is not likely to be induced.

Creation of a simple gastric fistula.

Operation.—The preliminary stages of this operation are similar to those described on page 79, etc. The operation then proceeds as follows :—

First Stage.—*Fixation of selected area of stomach.*—The selected portion of stomach, comprising a circle ¾ inch in diameter, is fixed to the margins of the upper portion of the parietal wound by the insertion of a series of fine silk sutures. As a general rule, eight to ten sutures are introduced on each side, and one above and one below. The lateral sutures are inserted thus : With dissecting forceps a portion of the stomach wall at the margin of the selected area is picked up, and then a half-curved needle armed with a suture is passed through the serous, muscular, and part of the submucous coats of the stomach, care being taken to avoid puncturing the mucous coat. If not more than a quarter of a third of an inch of the stomach wall is seized with the forceps the mucous coat slips away, and hence is out of danger. Next, the needle is passed through the abdominal wall, all the layers being included except the vertical fibres of the rectus abdominis muscle, about ¼ inch from the incised margins. Sutures are introduced in this manner for the entire length of each margin of the selected area. Then, the end sutures are inserted. An armed needle is passed through one margin of the parietal incision, commencing on the skin aspect ; next through the serous, muscular, and submucous coats of the stomach at one extremity of the selected area ; and finally, through the abdominal wall in the corresponding part of the opposite margin of the parietal incision, so that the needle emerges from the skin surface. A similar end suture is passed at the other extremity of the selected area ; and, finally, salmon-gut sutures are inserted so as to close the remaining portions of the parietal incision. Now the sutures are tied—first the lateral silk sutures ; secondly, the end silk sutures ; and then the salmon-gut sutures.

A small guiding suture is passed through the serous and muscular coats of the stomach in the centre of the selected area, and dressings applied. The first stage of the operation is thus completed. The patient is kept at rest and fed on very light and easily digestible foods for from three to five days, and then the second and final stage of the operation is carried out.

Second Stage.—*Opening of stomach.*—The dressings are removed, lymph and serous discharge sponged from the surface of the selected area of the stomach, and the guiding suture picked up. A sharp tenotome or very narrow-bladed scalpel is taken, and pushed through the stomach wall at the point of attachment of the "guiding suture." A piece of thin rubber tubing, or a gum elastic catheter, is then passed along the tenotome into the lumen of the stomach, and the instrument withdrawn. This tube is fixed in position by a suture, and through it small quantities of liquid food are introduced. The surfaces of the wound are carefully packed with antiseptic dressings, and the opening in the rubber tube or catheter temporarily closed. The administration of an anæsthetic is not necessary for this stage.

The advantages which have been claimed for this operation are—(*a*) The small amount of risk of peritonitis; (*b*) the applicability of the operation to nearly all patients suffering from carcinomatous affections of the œsophagus; and (*c*) the small amount of shock which is produced by the actual operation. The disadvantages of the operation are—(*a*) The tendency to leakage of stomach contents, and the consequent causation of an eczematous condition of the skin at the margin of the fistulous opening; and (*b*) the possibility of opening the peritoneal cavity at the second stage of the operation, and subsequent feeding of the patient into the peritoneum.

Gastrotomy.—The term gastrotomy implies the making of an opening through the wall of the stomach. This opening is usually closed immediately after the object of the operation has been attained.

Indications for operation.—Gastrotomy has been performed for the following conditions:—

(*a*) The presence within the stomach of a foreign body which will not readily pass through the pylorus.

(*b*) Fibrous constriction of the pylorus, or of the lower portion of the œsophagus.

(*c*) Impaction of a foreign body in the lower part of the œsophagus.

(*d*) For the arrest of hæmorrhage from a gastric ulcer.

Special instruments.—As for gastrostomy.

Position.—The patient is placed in the dorsal position, the operator stands on the left side, and the chief assistant opposite to him.

Before commencing the operation it is advisable to wash out the stomach with a dilute alkaline solution, so as to render it as aseptic as possible, and diminish the risk of the occurrence of peritonitis.

Operation.—The operation of gastrotomy may be divided into four stages, namely—

(*a*) *Abdominal incision.*—An incision 3 inches in length is made usually about 1½ inches to the left of the middle line over the left rectus abdominis muscle and parallel with the direction of its fibres; the sheath is thus opened and the muscle drawn outwards, so that the posterior portion of the sheath may then be divided and the abdominal cavity opened in the line of the skin incision. If the operation is performed for the removal of a foreign body, and the situation of this can be felt, the incision is usually made over it; and if it is being done for the relief of a fibrous constriction of the pylorus, the incision is made ½ inch to the right of the linea alba.

(*b*) *Finding the stomach, bringing it into the parietal wound, and location of the foreign body or other pathological condition.*—The fingers are introduced into the wound, and the stomach felt for, and also the locality of the foreign body, fibrous constriction, or growth. If a sharp foreign body is present, care must be taken when palpating the stomach not to cause injury to the walls. The stomach is then brought into the parietal wound, and the surrounding portion of the peritoneal cavity packed off with flat gauze-covered wool sponges or flat pads.

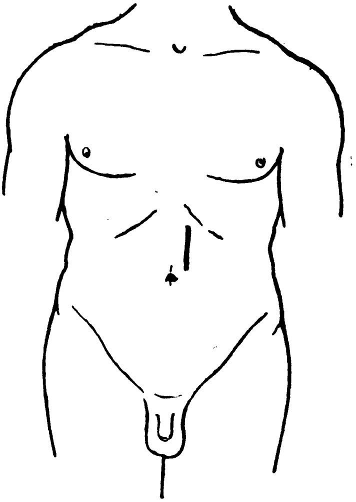

FIG. 93.—Gastrotomy. External incision.

(*c*) *Incision of the stomach wall and removal of the foreign body, or treatment of the special pathological condition for which the operation is undertaken.*—An incision is made through the stomach wall in a direction at right angles to the long axis of the viscus, so as to avoid injury to the chief blood vessels. The length of this incision varies according to the size of the foreign body which it is wished to remove, or to the nature of the constriction, or the size and locality of the malignant growth. The foreign body is removed through the aperture thus made, care being taken not to lacerate or damage the walls of the stomach. If the operation is performed for the relief of a fibrous stricture, either of the pylorus or the lower portion of the œsophagus, the forefinger of the right hand is passed into the cavity of the stomach towards the seat of the constriction, and the narrowed portion of the canal dilated by gently forcing the finger or graduated bougies through the stenosed part.

(*d*) *Closure of wound.*—The area of the wound in the stomach wall is carefully sponged and the aperture closed. The mucous membrane is joined to mucous membrane by the insertion of a continuous suture of chromicised catgut, the muscular and serous coats are united with interrupted sutures of fine silk, and the serous and superficial muscular coats by the insertion of a series of Lembert's sutures. When the incision in the stomach has been closed thus, all sponges are removed from the peritoneal cavity, and the exposed peritoneum carefully cleansed. The parietal wound is then closed in the usual manner.

The operation of gastrotomy, when it is performed for the dilatation of a fibrous stricture of the pylorus, has been called "Loreta's operation."

Gastrectomy.—This operation comprises removal of a part or the whole of the stomach. The so-called "complete" gastrectomy, or excision of the entire viscus, which has been performed only a very limited number of times, has consisted in removal of the greater portion of this organ—a small part of the cardiac end usually being left, in order to make a satisfactory anastomosis with the duodenum, or with the jejunum.

Indications.—(*a*) Localised destruction of the stomach walls, due to injuries from without or ulceration from within, where the damage has been so great that removal of the injured parts is deemed advisable before proceeding to repair the lesion by a plastic operation.

(*b*) Carcinoma, affecting a limited portion of the stomach wall, and not associated with visceral secondary growths. The presence of secondary growths in the lymph glands which lie along the curvatures of the stomach does not contra-indicate operation, since these can be removed along with the affected portion of the stomach. The existence of adhesions between the part of the stomach which is the seat of malignant disease, and adjacent abdominal viscera, especially the liver, usually contra-indicates the performance of gastrectomy.

(*c*) Sarcoma of the stomach, when there are no secondary visceral growths or implication of surrounding structures.

Special instruments.—Large intestinal clamps and rubber tubing.

Position.—The patient is placed in the dorsal position. The operator stands on the right side, and the chief assistant opposite to him.

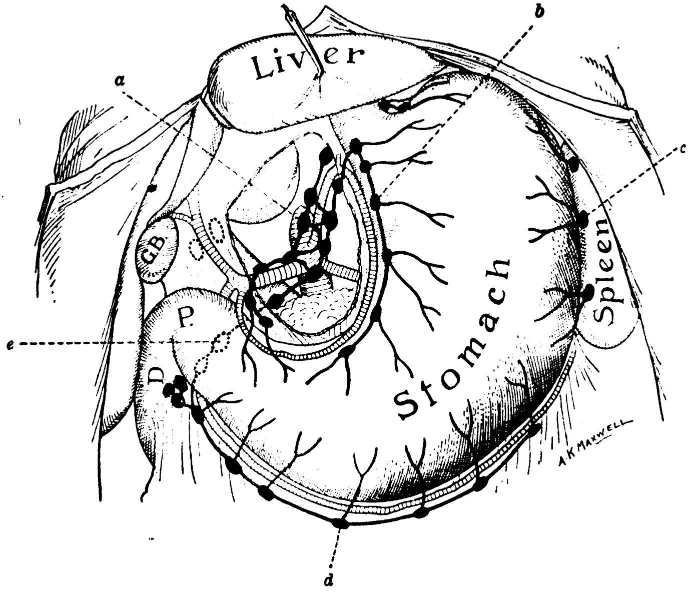

FIG. 94.—Lymph vessels and glands of the stomach. (From a specimen in which all the glands in the abdomen showed slight general enlargement.)

a. Large glands around the origin of the cœliac axis artery at the superior border of the pancreas.
b. Superior gastric glands.
c. Splenic glands.
d. Inferior gastric glands.
e. Sub-pyloric glands.
D. Duodenum.
P. Pylorus.

Operation.—The operation of gastrectomy may be divided into four stages—

(*a*) *Abdominal incision.*—An incision 3 to 4 inches long, similar to that in gastrotomy (Fig. 93), is made about 1½ inches to the left of the middle line, commencing 1 inch below the costal margin and extending vertically downwards. The various strata of the abdominal wall are successively divided, the rectus abdominis muscle being separated parallel with its fibres, and the peritoneal cavity opened. Should the incision prove insufficient, a second incision may be made at right angles to it, through one of the lineæ transversæ, if possible, so that a ⊢-shaped opening results. In this manner less dragging upon the stomach is necessary, and the patient suffers less from shock.

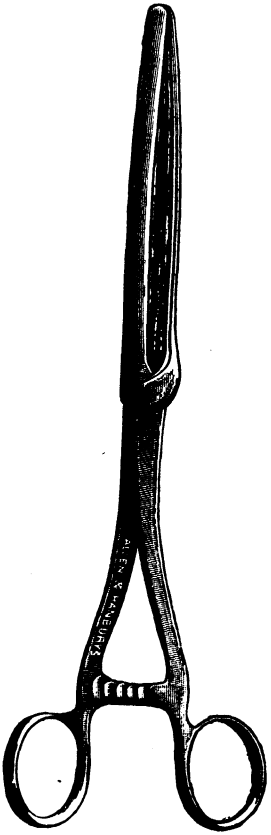

FIG. 95.—Large clamp for use in gastrectomy.

(*b*) *Finding of the stomach, location of the lesion, and determination of the part to be removed.*—The margins of the parietal incision are separated with wide abdominal retractors, and a careful inspection made of the stomach and its surroundings, so as to discover the limits and extent of the lesion or malignant growth, and so determine the lines where resection of the stomach and duodenum is to be effected. These lines of resection ought to be at least 1 inch on each side of the margins of a malignant tumour. At this stage of the procedure a careful investigation of the liver, and the lymph glands in the hepato-gastric ligament and in front of the spinal column, should be carried out, so as to eliminate the presence of any cancerous deposits in these regions, since, if any are found in the liver or lymph glands in front of the spinal column, the operation ought to be abandoned. When, however, the lymph glands in the hepato-gastric ligament are alone involved, the operation may be completed, and all implicated lymph glands and vessels excised.

The stomach is next brought forward into the wound, with the diseased area presenting, and the surrounding portions of the peritoneal cavity packed off with flat gauze-covered wool sponges or cellular pads. The large intestinal clamps (Fig. 95) are now taken and placed, one on the proximal side of the part which is to be removed and the other on the distal, each clamp being applied about 2½ inches from the margins of the diseased portion, or an inch or more from the lines where it has been determined to perform resection. When applying the proximal clamp, a small aperture should be made in the gastro-colic ligament, so as to allow one blade of the clamp to be passed behind the stomach. The distal clamp is applied to the duodenum, or to the pyloric portion of the stomach, according to the necessities of the individual case. These clamps control hæmorrhage, prevent escape of intestinal contents during the operation, and enable the assistant to hold the stomach well in the wound, thus materially helping the operator.

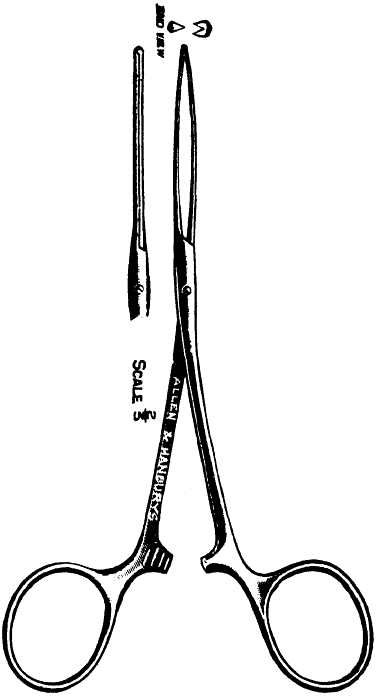

Fig. 96.—Clamp.

(*c*) *Separation and removal of required portion.*—The stomach being lifted forwards by the assistant in charge of the clamps, separation of the required portion is commenced by the surgeon cutting through with scissors the hepato-gastric ligament (small omentum) a short distance above its attachment to the small curvature of the stomach, and the gastro-colic ligament and part of the great omentum just below their attachments to the great curvature. The main branches of the right and left gastric and right and left gastro-epiploic arteries which lie along the curvatures of the stomach should be seized with pressure forceps before being divided, and any other bleeding vessels picked up and ligatured. The portion of omental bursa which has been opened up should be packed with a flat sponge or pad, so as to prevent unnecessary contamination with any contents of the stomach which may escape. The incisions through the stomach, or stomach and duodenum, are now made, care being taken to carry them as far as possible at right angles to the long axis of the viscus. Commencing above, the stomach is divided transversely by cutting with strong, blunt-pointed scissors or the knife of the thermo-cautery ; and, as the section is made, the cut margins on the part to be removed are seized with strong pressure forceps, which serve to lift up the mass. When possible, pairs of large stomach clamps should be placed on each side of the portion of the stomach it is proposed to remove, in order to prevent contamination or soiling of the field of operation by the contents of the stomach. Any bleeding points on the cut margin on the proximal side are picked up with pressure forceps and ligatured. Next, the section of the stomach or duodenum on the distal side is made in a similar manner ; in this way the mass to be removed is entirely separated and can be taken away. The cut margin of the distal portion of the duodenum is next examined, and any bleeding arrested by the application of ligatures. At this stage the intestinal clamps should be relaxed, so as to render apparent any divided blood vessels, which have so far evaded observation and not been ligatured. Enlarged lymph glands are sought for in the positions shown in Fig. 94 and removed. The area of operation is now thoroughly sponged or irrigated, so as to remove any blood-clot or escaped stomach contents.

(*d*) *Anastomosis of cut ends of stomach and duodenum.*—The cut ends of the proximal portion of the stomach and the duodenum are brought into apposition, and if they correspond in size they are at once united ; but if the opening in the stomach is too large, a portion of it is closed by suturing together the cut margins with a continuous suture of chromicised catgut, which pierces the entire thickness of the stomach wall. The edges are then inverted by a series of silk sutures, introduced after Lembert's method, or by a continuous suture with several interruptions.

When the opening in the stomach has been reduced to a suitable calibre, the edges of the openings in the stomach and duodenum are brought together and fixed by careful suturing. The cut edges of the stomach and duodenum are joined by a continuous suture of chromicised catgut, which passes through the entire thickness of the walls, the posterior part being sutured first. When this has been satisfactorily completed, the serous and muscular coats of the stomach and duodenum are fixed together either by a series of Lembert's silk sutures, introduced at intervals of one-sixth or one-eighth of an inch, or by a continuous suture with several interruptions. The anastomosis being completed, the area of operation is again sponged or irrigated, the sponges or pads which have been used for protecting the peritoneum and adjacent abdominal viscera removed, and the intestinal clamps taken off.

A roll of gauze is passed down to the area of operation, and one end brought out through an angle of the parietal wound.

(*e*) *Closure of parietal wound.*—The main portion of the incision is closed by the insertion of three tiers of sutures, whilst the upper portion is left open for the exit of the gauze which has been introduced for drainage purposes.

Pyloroplasty.—This operation, as practised by Heineke and Mikulicz in cases of fibrous stricture of the pylorus or the upper part of the duodenum, comprised opening the abdomen on one side of the middle line, and bringing the pylorus and the constricted portion of the duodenum into the parietal wound. The exposed portion of the alimentary canal was incised in its long axis for about 2 inches, and the margins of this incision approximated and fixed by the insertion of sutures in a transverse direction. The results obtained were not satisfactory, recurrence of the fibrous constriction being frequent, hence the operation in this form has been abandoned.

A modification of pyloroplasty has been devised by Finney, and modified by other operators, which has given good results in simple cases of fibrous contraction of the pylorus. Where, however, there are many adhesions surrounding the fibrous constriction, pyloroplasty is not recommended, better results being obtained by gastro-jejunostomy. This operation is performed as follows :—

Operation.—Finney's operation of gastro-duodenostomy with some slight modifications is performed thus :—

(*a*) *Parietal incision, exposure of pyloric portion of stomach, pylorus and first and second portions of duodenum, separation of adhesions, and full exposure of operation area.*—An incision three inches in length is made a little to the right of the middle line and between the processus xiphoideus (ensiform cartilage) and the umbilicus. The anterior layer of the sheath of the rectus abdominis is cut through, the fibres of the muscular mass separated vertically, and, after retraction of the margins of the wound, the posterior layer of the rectus sheath and the parietal peritoneum are incised in the line of the original incision. The peritoneal cavity being opened, the region of the gall bladder, pylorus, and duodenum is carefully examined in order to detect any adhesions or other pathological condition which may be present. Adhesions are broken down by sponge pressure or divided with scissors until the pyloric area is well exposed. Next, the peritoneum on the other side of the upper portion of the second part of the duodenum is cut in a vertical direction so as to enable the pylorus, duodenum, and constricted areas to be separated from their posterior connections and lifted up into the parietal wound. The separated pylorus and adjacent portions of stomach and duodenum are now lifted forward, and the adjacent

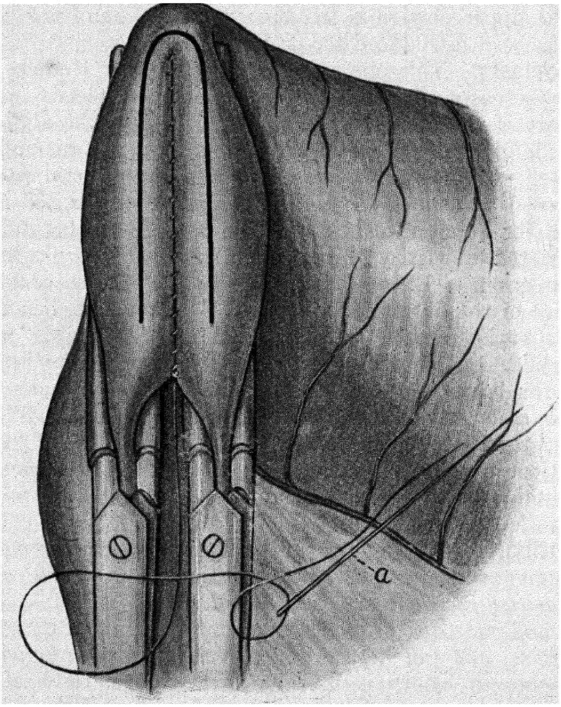

FIG. 97.—Gastro-duodenostomy for pyloric stenosis. (Modification of Finney's procedure.)

a. First sero-muscular suture inserted.
The black line shows the position of the incision in the anterior aspect of the stomach and duodenum.

viscera and peritoneum packed off and protected by the insertion of flat pads.

(*b*) *Application of clamps, insertion of first sero-muscular suture, creation of fistulous communication, and completion of sutures.*—Two rubber-covered long intestinal clamps are applied to the adjacent portions of the stomach and the duodenum in the manner shown in Fig. 97, and held parallel to one another by an assistant. A long suture of No. 1 silk is next taken and inserted so as to fix the approximated stomach and duodenum for about two inches, according to the method shown in Fig. 97. Incisions are now made through the walls of the stomach and duodenum, and the lumen of each cavity opened. A needle threaded with No. 2 chromicised catgut is now taken, and the margins of the openings in the stomach and duodenum sewn together by a through-and-through continuous suture, this suture commencing above, and posteriorly passing downwards, then forwards and upwards, and finally terminating at the point

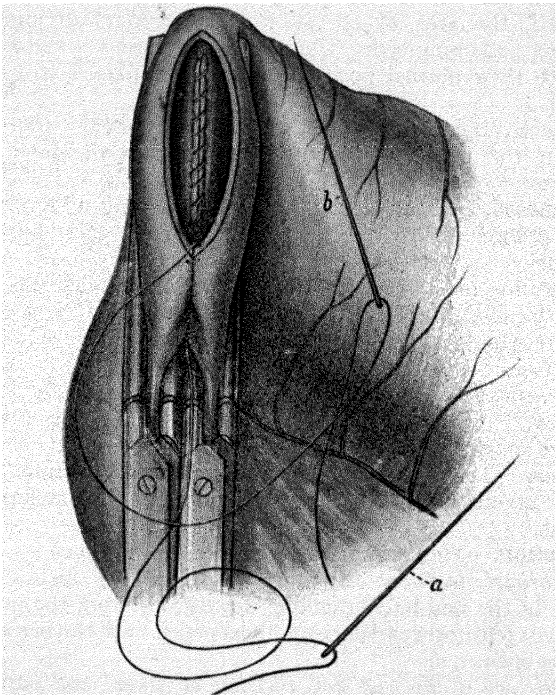

FIG. 98.—Gastro-duodenostomy for pyloric stenosis. The second suture is shown completed posteriorly and passing forwards to close opening anteriorly.

a. Sero-muscular suture. *b*. Through-and-through suture, which unites the margins of the anastomotic opening.

of commencement (Fig. 98). The rubber-covered clamps are now removed and the sero-muscular suture of No. 1 silk inserted in front of the last inserted catgut suture. If there is any doubt of the security of the approximation, several silk sutures, inserted after Lembert's method, may be put in to strengthen the united surfaces. The suturing having been completed, the area of operation is sponged clean and the protecting pads removed. The viscera are then allowed to fall back into their normal position, and any displaced structures replaced.

(*c*) *Closure of external wound.*—The external wound is closed in the usual fashion by the insertion of three tiers of sutures.

Rammstedt's Operation.—*Indications.*—Congenital hypertrophic pyloric stenosis when medical measures have failed to give relief.

Preparation for operation.—The stomach is washed out with sodium bicarbonate solution until the return is clear. The limbs are bandaged and a subcutaneous injection of normal saline given.

Anæsthetic.—The anæsthetic should be open ether, the induction slow, but deep anæsthesia must be induced to prevent excessive shock.

Position.—The patient is placed in the dorsal position. The operator stands on the patient's left side and the assistant on the right.

Operation.—This may be divided into three stages—

(*a*) *Parietal incision.*—An incision about 1½ inches long is made in the mid-line extending downwards from the process xiphoideus (ensiform cartilage), and deepened until the peritoneal cavity is open.

(*b*) *Delivery of pylorus and incision of serous and muscular coats.*—A finger of the left hand is introduced into the wound, and the hypertrophied pylorus felt and hooked up into the wound, this procedure tilting the anterior edge of the liver upwards. The pylorus is held gently between the finger and thumb of the left hand and an incision made along its anterior surface, care being taken to avoid blood vessels. This incision divides the serous and muscular coats of the pylorus and exposes the mucous membrane of the pyloric canal. Oozing is controlled by pressure with a hot sponge and the pylorus returned to the abdominal cavity.

(*c*) *Closure of the wound in the abdominal wall.*—The liver is allowed to fall back into place, thus preventing egress of intestines through the wound. The peritoneum is closed with fine catgut, the linea alba with catgut, and the skin with silkworm gut. The patient is returned to bed and a rectal saline with brandy administered.

Pylorectomy, or removal of the pyloric portion of the stomach.—In this operation the pyloric extremity of the stomach (pyloric canal), together with the adjacent parts of the duodenum and stomach, are removed through an abdominal incision, and then the opening in the stomach is partially closed, and that part which is left open is united to the open extremity of the duodenum.

Indications.—Removal of the pylorus is indicated in those cases of malignant disease of the pylorus in which the pathological process is strictly localised to this part of the alimentary canal, and when secondary cancerous deposits are limited to the lymph glands in the immediate neighbourhood of the pylorus. The operation should only be attempted in patients who are good subjects for surgical interference.

Preliminary preparations.—The day before the operation the stomach should be washed out with saline solution, and during the preceding few days easily digestible food, which has previously been sterilised, should be given. The teeth should be attended to if requisite, and the mouth kept as clean as possible by the frequent use of a tooth brush and an antiseptic mouth wash. The day previous an aperient should be administered, so as to empty the intestines as far as possible. Immediately before the patient comes into the operation room the stomach should be again washed out.

Special instruments.—Large intestinal clamps.

Position.—The patient is placed in the dorsal position, and near the right edge of the table. The operator stands on the right side, and the assistant directly opposite to him.

Operation.—The operation of pylorectomy may be divided into the following stages :—

(*a*) *Parietal incision.*—An incision 3 to 4 inches in length is made either in the linea alba or through the rectus abdominis 1 inch to the right of the middle line, usually the former, and situated over the most prominent part of the tumour. The various strata of the abdominal wall are divided in the usual manner until the peritoneal cavity has been opened.

(*b*) *Localisation, separation, and delivery of tumour and adjacent portion of alimentary canal.*—The fingers of the right hand are introduced into the peritoneal cavity, and the position of the disease in the pylorus defined. The adjacent coils of intestine and the great omentum are pushed out of the way and protected from injury by packing the region of the tumour with flat sponges. The pylorus is next brought out through the external wound. If its attachments to the great and small omenta will not allow this to be done, these structures are divided for a sufficient distance along the great and small curvatures of the stomach, and the cut edges tied with ligatures so as to arrest hæmorrhage. When the tumour has been brought well forward into the external wound its relations are determined. If it is found to be localised, and there are no signs of secondary growths in the liver, or in the region of the head of the pancreas (or elsewhere), its complete removal may be decided on.

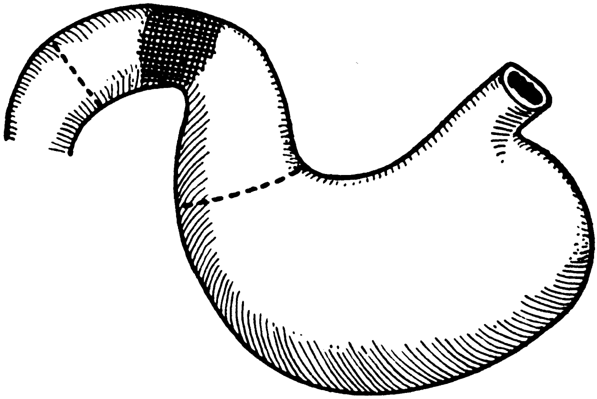

FIG. 99.—Pylorectomy. Lines of incision in stomach and duodenum. The dark portion represents the extent of the growth.

The presence of enlarged lymph glands between the layers of the hepato-gastric ligament (small omentum) adjacent to the diseased area do not contra-indicate operation, since these can be easily removed along with the diseased pylorus.

(*c*) *Removal of pylorus and affected portions of stomach and duodenum.*—Before commencing to remove the tumour, the contents of the adjacent portions of the stomach and duodenum (if any are present) are pushed onwards, and then an intestinal clamp is applied to the stomach about 2½ inches above the limits of the growth, and a second clamp to the duodenum an equal distance below it. These clamps prevent the escape of intestinal contents into the field of operation, and help the surgeon to control hæmorrhage without much difficulty.

When the clamps have been applied, the stomach and duodenum are divided with strong scissors, a scalpel, or the knife of the thermo-cautery, and the tumour freed from any other connections which it may have. Care must be taken in making these sections that the bile duct, the portal vein, and the hepatic artery are avoided. They lie behind the first portion of the duodenum, and then between the two layers of the hepato-gastric ligament (small omentum). The tumour having been removed, the cavities of the exposed parts of the stomach and duodenum are carefully sponged, and then the clamps are slightly loosened by the assistant, in order to allow hæmorrhage to take place from the divided vessels, and so facilitate the application of ligatures to them.

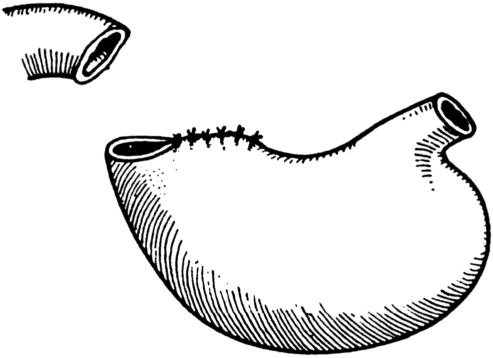

FIG. 100.—Pylorectomy.—Affected portions of gut removed, and part of incision in stomach closed by sutures.

(*d*) *Partial closure of wound in stomach and union of other part to cut end of duodenum.*—A part of the divided end of the stomach is united, according to the method shown in Fig. 100. The best method of doing this is by the insertion of a continuous suture of chromicised catgut through the entire thickness of the margins of the wound, the mucous membrane being inverted; and when this has been done a series of Lembert's sutures are inserted, as in Fig. 100. The next stage is the union of the remainder of the wound in the stomach to the open extremity of the duodenum, and hence the re-establishment of the continuity of the alimentary canal, or complete closure of cut ends of stomach and duodenum, and establishment of a fresh communication by performing a posterior gastro-enterostomy. If the growth is a limited one the former procedure is the better, but if a considerable amount of stomach has to be removed the latter will be found the easier to perform, and give better results.

Sutures only.—The mucous membrane and the muscular and serous coats of the stomach are united to the corresponding portions of the duodenum by a continuous suture with several interruptions of chromicised catgut. This stitching is commenced posteriorly, and continued forwards until the entire circumference of the bowel has been sewn up. As the suture is inserted a few knots or interruptions should be made, each knot being towards the lumen of the gut. Next, the line of suture is well sponged so as to remove all traces of blood or stomach contents, and then the line of approximation is further united by the insertion of a circle of Lembert's sutures, which transfix the serous, muscular, and submucous coats only. When these have been tied and the ends cut short the union is completed. If there is any doubt as regards the security of the sutures, it has been recommended that a graft of omentum should be fastened to the suspected portion.

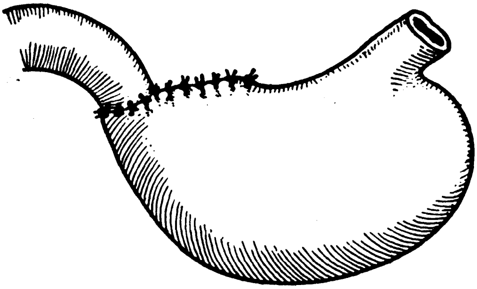

FIG. 101.—Pylorectomy. Stomach and duodenum united by sutures.

Mechanical appliances such as anastomosis buttons, and bone tubes or bobbins, have been used in the past in order to facilitate the union of stomach and duodenum, but their use has now been discarded by most surgeons since better apposition can be obtained by good suture methods.

Complete closure of cut ends and establishment of gastro-intestinal anastomosis.—This operation may also be finished by completely closing the openings in both the stomach and duodenum, and then bringing a loop of jejunum into apposition with the posterior wall of the stomach, and performing a lateral anastomosis, as in the operation for gastro-enterostomy (see p. 105 *et seq.*). The advantages of this method are that those parts recently adjacent to the disease are not subject to the irritation of the passage of food, and therefore the risk of recurrence in the case of carcinoma is minimised; also that, although an apparently severer operation, most patients improve more quickly, and the period of convalescence is shorter, than in the previous operations.

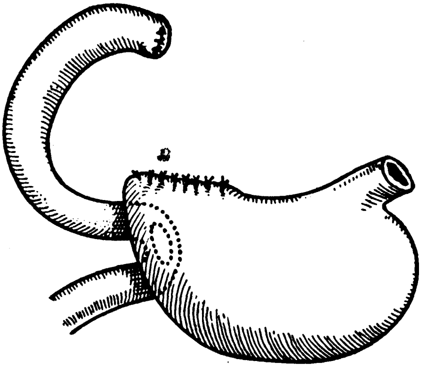

FIG. 102.—Pylorectomy. Cut ends of stomach and duodenum closed, and lateral gastro-intestinal anastomosis established.

(*e*) *Return of stomach and duodenum into abdomen, and closure of external wound.*—After the approximation of the divided portions of the alimentary canal has been completed, all the sutures are cut short, the region of operation and the adjacent part of the peritoneal cavity are well sponged, so as to remove all blood and other material which may have escaped, and then the stomach and duodenum are returned within the abdomen. The external wound is finally closed by sutures in the usual manner. No drainage is necessary.

After-treatment.—No food should be given by the mouth for the first twenty-four or thirty-six hours, the strength of the patient being maintained during this period by the administration of nutrient enemata. Afterwards, feeding by the mouth is commenced, small quantities being given at first. Only fluid foods should be given, and these should be rendered sterile, if possible, before administration.

Partial Gastrectomy.

Special instruments.—Self-retaining retractors, stomach and intestinal clamps, gastro-enterostomy forceps, round-bodied needles.

Position.—The patient lies in the dorsal position, with the surgeon standing to the right and the first assistant opposite him. The table should be placed so that the main light is from above and slightly nearer the foot than the head.

Operation.—The abdomen is opened by a vertical incision starting at the costal margin 1½ inches to the right of the mid-line, the rectus muscle being retracted outwards. The diseased portion of the stomach is carefully examined and enlarged lymph glands are sought for (Fig. 94). A finger is passed into the epiploic foramen (of Winslow) and the bursa omentalis (lesser sac) is examined and any adhesions or hard or enlarged lymph glands noted. The liver is next examined for secondary deposits of malignant disease, the presence of which would offer an absolute contra-indication to the operation. The abdominal wound is retracted and the surgeon passes his left hand over the fundus of the stomach and lifts the stomach gently forward and to the right. A large swab or small towel wrung out from hot saline is passed into the hollow beneath the fundus and in front of and above the spleen. In this way the whole stomach is kept forward without traction and therefore with a considerable diminution in shock.

The field of operation is now packed off with hot swabs. The right gastric (pyloric) artery is ligatured in two places and cut across. The peritoneum along the upper border of the first part of the duodenum is incised, the hepatic artery, portal vein and common bile duct carefully separated from the posterior aspect of the gut. A finger is passed behind the first part of the duodenum and this is lifted up and its lower attachments separated. Two clamps, the distal one of which must be of a crushing variety, are placed across the freed portion of the duodenum and this is divided between them with the thermo-cautery knife. A blind end is thus made in the distal portion of this divided duodenum. The pylorus is now turned upwards and to the left and the right gastro-epiploic artery ligatured and divided at its origin. The left gastric (coronary) artery is sought for at its origin from the cœliac axis and ligatured in continuity and then divided. The remaining attachment of the gastro-hepatic omentum to the lesser curvature can now be ligatured in bundles and divided, care being taken to leave the lymph glands on the stomach side of the divided ligament. Any adhesions to the pancreas are separated and a hot saline swab is placed into the bursa omentalis (lesser peritoneal sac). The left gastro-epiploic artery is next divided at a point near the greater curvature of the stomach immediately opposite to the right margin of the cardiac orifice. The separation of the great omentum from the stomach requires the greatest care. All lymph glands must be removed and these often lie some distance from the organ, and it is imperative that the middle colic artery shall escape injury. With these two points in mind a site is found and the omentum is divided between lines of interlocking sectures.

A rubber-covered clamp is now passed vertically from the greater curvature to the right margin of the œsophageal opening, and the stomach is turned over to the left, bringing the posterior surface upwards. A loop of jejunum, selected as for gastro-enterostomy, is now brought up *in front* of the transverse colon and laid against the stomach so that the proximal end of the gut is approximated to the greater curvature, and the distal end to the lesser curvature. A gastro-enterostomy forceps is applied to the loop and, with a sero-muscular suture of chromicised catgut, the jejunum is fixed to the posterior wall of the stomach just proximal to the intended line of section. The sero-muscular coats of the jejunum are divided parallel to the line of sutures and the sero-muscular coats of the posterior wall of the stomach are divided in the same way, leaving the mucous membrane intact. The stomach is turned back and the incision in the stomach carried round to the under surface. The distal portion of the stomach is now clamped and removed by dividing the exposed mucous membrane. The mucous membrane of the jejunum is opened and the anastomosis of the jejunum and stomach is completed as in posterior gastro-enterostomy. The clamp from the proximal end of the stomach is removed. The swabs are removed from the abdomen and the stomach is found to retract into the left hypochondrium, leaving the jejunum to the left of the splenic flexum.

Gastro-enterostomy.—The establishment of an artificial communication between the cavity of the stomach and that of the intestine is called " gastro-enterostomy " ; if the duodenum is the part of the intestine to which the stomach is attached, the operation is known as " gastro-duodenostomy " ; if the jejunum, "gastro-jejunostomy"; and if the ileum, "gastro-ileostomy." Gastro-duodenostomy and gastro-ileostomy, however, are now very rarely practised, and by gastro-enterostomy is usually understood anastomosis between the stomach and the upper part of the jejunum.

Indications.—The operation of gastro-enterostomy is indicated in the following clinical conditions, namely—

(*a*) In those cases of malignant disease of the pylorus in which it is not advisable to attempt local removal of the growth, and in which it is probable that life will be prolonged by the establishment of an artificial communication between the stomach and the intestine.

(*b*) Carcinoma of the body of the stomach which is causing contraction and obstruction, and in which there is sufficient room on the proximal side to allow of union between the jejunum and sound stomach wall.

(*c*) In certain cases of severe fibrous stricture of the pylorus or duodenum, which cannot be satisfactorily treated by "pyloroplasty."

(*d*) Certain cases of chronic ulcer of the stomach, especially those in which the ulcer is in the pyloric portion and has caused adhesion to the surrounding parts.

(*e*) Some cases of duodenal ulcer, when it is not considered advisable to excise the ulcer itself.

(*f*) In some cases of cancer of the pyloric portion of the stomach when, although the local affection is capable of treatment by removal, the general condition of the patient will not allow so severe an operation to be carried out without undue risk. Thus a gastro-enterostomy may be done, and some time later the cancerous growth may be removed.

Position.—The patient is placed in the dorsal position, the surgeon stands on the right side of the patient and the assistant on the left.

Varieties.—There are two chief varieties or methods of performing the operation of gastro-enterostomy—in one a loop of the jejunum is anastomosed with the *anterior* aspect of the stomach immediately above the greater curvature, and in the other the portion of jejunum just beyond the duodeno-jejunal flexure is joined to the *posterior* aspect of the stomach a little above the greater curvature, after an opening has been made in the transverse meso-colon from its posterior or vertebral aspect. An extended experience of these operations has shown that the *posterior* operation is the better, owing to the results which have followed. There is far less risk of persistent vomiting and the establishment of a " vicious circle," and pressure upon the transverse colon is avoided.

When, however, the posterior wall of the stomach is the seat of disease, or there are extensive peritoneal adhesions in the bursa omentalis (lesser sac of the peritoneum), or the transverse meso-colon is very short, then the *anterior* should be recommended. It therefore follows, when gastro-enterostomy has been decided upon, that the *posterior* operation should always be performed, unless there are distinct contra-indications such as those mentioned above, in which case the *anterior* should be adopted.

Both operations will now be described.

Posterior gastro-enterostomy.—*Preliminary preparation of patient.*—When the stomach is dilated it should be washed out twice daily with sterilised water or saline solution; but when there is no evidence of such complication one washing out the evening before the operation will be found to suffice. The teeth and mouth should be attended to, and rendered as aseptic as possible, and no food given by the mouth for six hours previous to the performance of the operation.

Special instruments.— Intestinal clamps, rubber tubing.

Operation. — The operation of gastro-enterostomy may be conveniently performed in the following stages :—

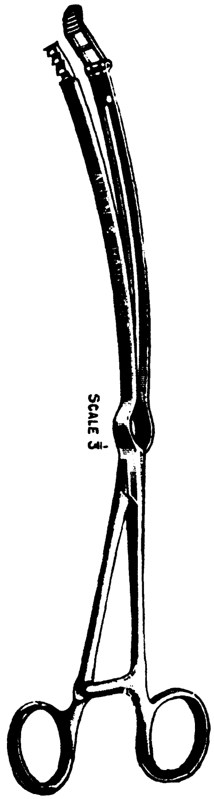

FIG. 103.—Intestinal clamp.

(*a*) *Parietal incision.*—An incision from 3 to 4 inches in length is made ½ inch to the left of the linea alba, commencing a short distance below the processus xiphoideus (ensiform cartilage), and extending to the umbilicus. This incision is extended until the peritoneal cavity has been opened.

(*b*) *Finding of stomach and required portion of intestine, and* *bringing them out into the external wound.*—The portion of the intestine which is usually selected is the jejunum just beyond the termination of the duodenum. The great omentum and transverse colon are brought out of the wound and turned upwards and toward the right; then a coil of small intestine, which lies upon the vertebral column and at the level of the lower pole of the left kidney, is taken and traced upwards; if it is the jejunum, it will be found to have a short mesentery at its upper part, and to turn upon itself and become continuous with the duodenum. When this has been verified, the first portion of the jejunum is emptied of its contents by passing it between the fingers, and an intestinal clamp is applied in the manner shown in Fig. 104. A vertical opening about 2 inches long is next made in the transverse meso-colon from the posterior aspect, care being taken to avoid the blood vessels. The omental bursa (lesser sac) is thus opened and the posterior aspect of the stomach exposed. Pressure from above is now applied with the fingers above the

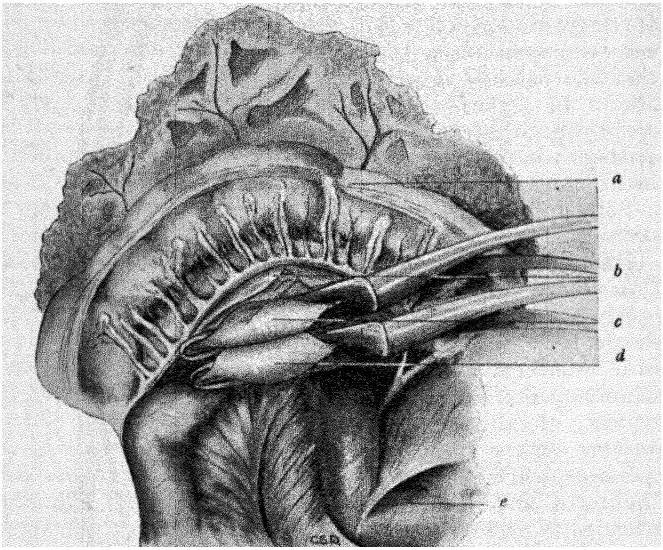

FIG. 104.—Gastro-enterostomy. Posterior operation. Application of clamps to loop of jejunum, and a portion of posterior part of stomach.

a. Transverse colon.
b. Aperture in meso-colon.
c. Stomach.
d. Jejunum.
e. Duodenum.

transverse colon, and the stomach made to project through the opening in the transverse meso-colon. The lowest portion of the stomach immediately above the great curvature, and as near the pyloric extremity as possible without exerting tension, is selected. The main blood vessels of this portion of the stomach run at right angles to the greater curvature and the opening into the organ should be made parallel to them to minimise the risk of hæmorrhage. The clamp is applied to the selected portion of stomach at right angles to the greater curvature and then adjusted so that it lies parallel to the clamped portion of the jejunum as in Fig. 104. The portions of stomach and jejunum are now surrounded with flat gauze sponges, and the adjacent viscera protected in a similar manner; the clamps holding the selected portions of stomach and jejunum being held parallel to one another and close together by an assistant as in Fig. 104. The formation of the anastomosis may now be performed.

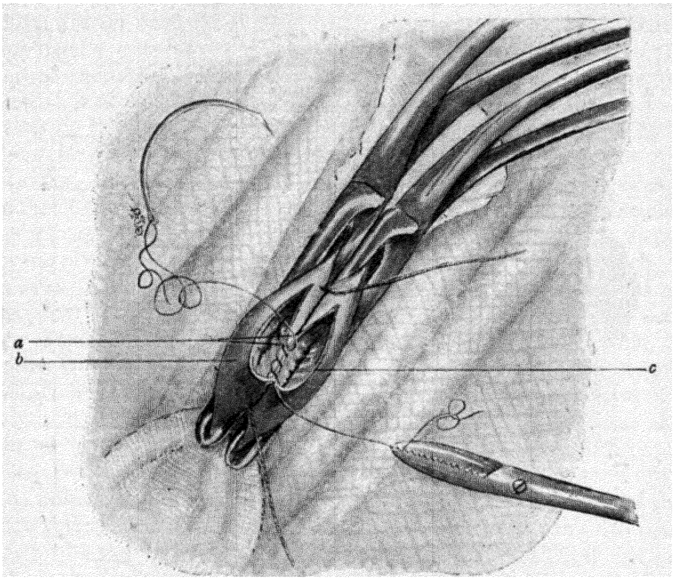

FIG. 105.—Gastro-enterostomy. Posterior operation. Portions of stomach and jejunum in apposition, showing incisions in both, and method of inserting suture joining the cut margins.

a. Catgut suture joining margins of incisions.
b. Stomach.
c. Jejunum.

(*c*) *Formation of anastomosis between stomach and intestine.*—The loop of jejunum being applied to the stomach with a strip of gauze behind and between them, any small branches of the gastro-epiploic arteries which can be seen passing across the exposed portion of stomach are ligatured, in order to avoid hæmorrhage when the opening is made into the viscus. The serous surfaces of the stomach and jejunum are fixed in apposition for a distance of 2½ inches by the insertion of a continuous suture of No. 1 silk, or celloidin thread, with about two interruptions, the needle being then laid aside but left threaded. About ¼ inch in front of this line of suture the stomach and jejunum are incised for 2 inches, the lumen of each viscus being opened for the entire length of the incision. The margins of

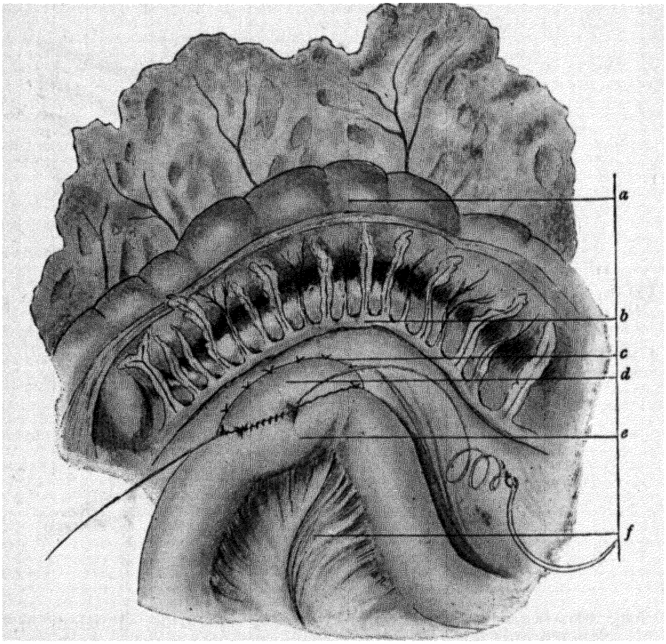

FIG. 106.—Gastro-enterostomy. Posterior operation. Anastomosis of stomach and jejunum completed.

a. Transverse colon.
b. Meso-colon.
c. Aperture in meso-colon sutured to stomach.
d. Stomach.
e. Jejunum.
f. Mesentery of jejunum.

these incisions are then united all the way round, after any protuberant mucous membrane of stomach or jejunum has been cut away, by the insertion of a continuous suture of chromicised catgut, with several points of interruption (Fig. 105). This suture should commence at the left extremity of the two incisions and first pierce the jejunum, passing from the mucous aspect to the serous, and then stomach from serous to mucous aspects, a knot being then tied. A continuous suture is now carried along the posterior margins of the new anastomotic opening, the suturing needle passing from jejunal mucous membrane to jejunal serous membrane, and then from gastric serous membrane to gastric mucous membrane. When the posterior portion of the suturing has been completed, the return half of the suture, which fixes the anterior margins of the anastomotic opening in close apposition, is best inserted by the method known as the " pillow-maker's stitch." When the right extremity of the suture line has been reached and the needle has passed from the mucous membrane of the jejunum to the mucous membrane of the stomach, it is again passed through the wall of the stomach from mucous to serous surfaces, forming a loop on the mucous membrane. Next the needle traverses the jejunum twice, first from serous to mucous aspects, then from mucous to serous, a loop of suture being thus formed on the mucous aspect of the bowel. After the suture is introduced in the above manner and drawn taut the serous aspects of the stomach and duodenum turn in and come into close apposition. This method of suturing is continued until the point of commencement is reached at the left extremity of the new anastomotic aperture. The two ends of the suture are then tied and the ends cut short. If there are any bleeding vessels along the line of suture they should be picked up and tied. The line of suturing is sponged dry, the clamps loosened, and the first line of suturing completed along the anterior surface by taking up the needle attached to the first suture and continuing the suture from right to left. When the left extremity has been reached the suture in the needle is knotted with the long end which was left for the purpose at the commencement of the suturing. The exposed surfaces of stomach and jejunum are now sponged with saline solution, the protecting gauze sponges removed, and the clamps taken off. The margins of the opening in the transverse meso-colon are fixed to the surface of the stomach by several points of interrupted suture (Fig. 106, *c*) As an extra precaution it is usually advisable to put in two or three sutures, so as to fix the stomach and jejunum together just beyond the lower part of the circular serous suture, in order to prevent retraction of the jejunal loop upwards. The stomach and jejunum thus fixed together are returned into the abdominal cavity, care being taken to place the jejunum on the right side of the spinal column. The great omentum and transverse colon are then pushed downwards into their normal position in front of the small intestines.

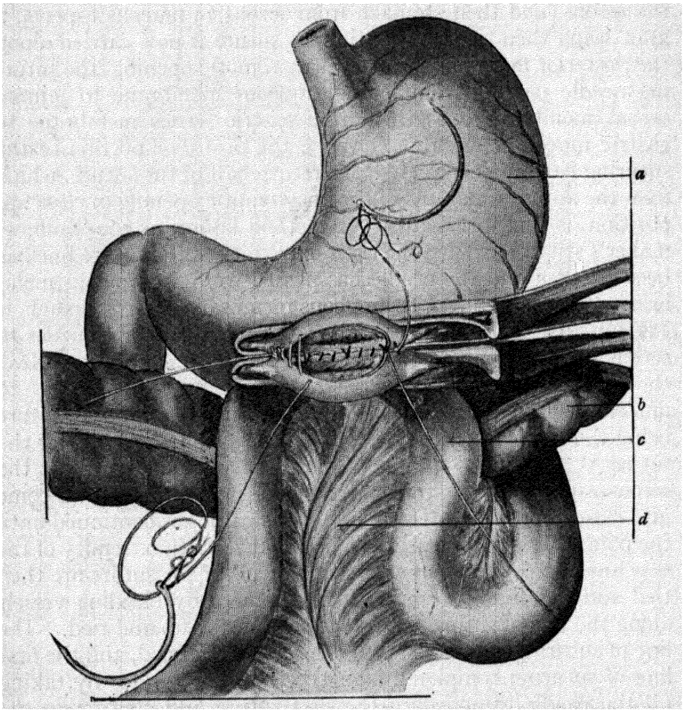

FIG. 107.—Gastro-enterostomy. Anterior operation. Selected portion of stomach and jejunum in apposition, continuous sutures uniting margins of anastomotic aperture being inserted.

a. Stomach.
b. Transverse colon.
c. Jejunum.
d. Mesentery of jejunum.

(*d*) *Closure of external wound.*—When the anastomosis has been completed, the viscera returned into the abdomen, all protecting sponges removed, and the contaminated part of the peritoneum (if any) well sponged, the margins of the parietal incision are united in the ordinary manner by the insertion of three tiers of sutures.

Anterior Gastro-enterostomy.—The positions of the patient, operator, and assistants are the same as in the previous operation.

Operation.—The abdomen is opened as in posterior gastro-enterostomy, and the position of the stomach defined. The great omentum and transverse colon are pulled upwards and towards the right, and the duodeno-jejunal flexure exposed on the left side of the vertebral column, and immediately above the lower pole of the left kidney. The first loop of the jejunum beyond the flexure is brought into the wound, together with the anterior portion of the stomach where it is proposed to fix the anastomosis. This should be in the lower or most dependent part of the stomach immediately above the greater curvature, and as near the pylorus as the conditions will allow.

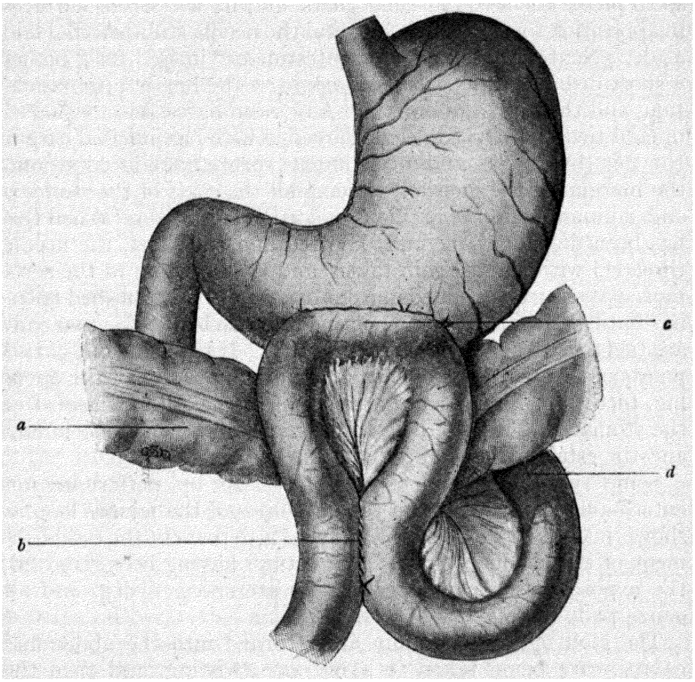

FIG. 108.—Gastro-enterostomy. Anterior operation. Anastomosis completed.

a. Transverse colon.
b. Anastomosis between two loops of jejunum.
c. Jejunum.
d. Termination of duodenum.

The loop of intestine, which is usually 14 to 18 inches long, is emptied of its contents by passing between the fingers, and a rubber-covered clamp applied at each extremity. It is then fixed to the selected area of the stomach wall thus. The stomach being held either with a clamp or the fingers of an assistant, a continuous suture of No. 1 silk, or celloidin thread, is introduced so as to pierce the sero-muscular coats, and fix the serous surfaces in apposition for about 3 inches, and the needle still threaded laid aside. Next, the stomach and intestine are incised for 2 inches a short distance away from and opposite the line of approximation, and their cavities opened. Any bleeding vessels are picked up and tied. A curved needle threaded with chromicised catgut No. 2 is thus taken, and a continuous suture introduced around the margins of the incision, piercing all the coats of the stomach and jejunum as in the previous operation (Fig. 107). When this has been done, and the ends knotted and cut short, the needle threaded with silk is again taken, and the insertion of the sero-muscular suture continued in front of the newly-established opening until the point of commencement is reached. The two ends are tied together and cut short (Fig. 108). If requisite, one or two points of suture are introduced on the proximal side of the opening, further to fix the loop of jejunum to the anterior aspect of the stomach. This will help to prevent kinking of the jejunum and the establishment of a " vicious " circle.

Some surgeons complete this operation by performing an entero-anastomosis between the two limbs of the jejunal loop as shown in Fig. 108. The object of this is to prevent the establishment of a " vicious " circle. The clamps having been removed, the exposed viscera and peritoneum are sponged dry, and all gauze pads removed.

The stomach and jejunum are returned into the abdominal cavity, care being taken to avoid any twisting, and then the parietal wound is closed by the insertion of three tiers of sutures.

Treatment of perforated gastric ulcers.—Ulcers of the stomach which lead to perforation of the walls may be either of the " acute perforating," sub-acute, or the " chronic " variety. The perforation usually occurs suddenly, without any premonitory symptoms having been manifested. Immediately the diagnosis has been made that an ulcer of this kind has perforated the stomach wall, an operation for the relief of the condition ought to be carried out.

The symptoms of shock, which in all cases supervene after the occurrence of perforation, must be combated by the administration of rectal saline injections, in order that the patient may not be too collapsed to withstand the further shock due to the operation.

Position.—The patient is placed in the dorsal position on the operation table, the surgeon stands on the right side and his assistant on the left.

Operation.—The operation may be divided into several stages namely :—

(*a*) *External incision.*—An incision is made ½ inch to the left of the linea alba, commencing immediately below the lower border of the processus xiphoideus (ensiform cartilage), and extends downwards towards the umbilicus for a distance of 3 or 4 inches. This incision is deepened until the peritoneal cavity has been opened, all hæmorrhage from the parietal vessels being arrested.

(*b*) *Finding of stomach and perforation.*—The anterior surface of the stomach can usually be seen at the bottom of the wound.

The adjacent coils of small intestine, if they protrude, are held aside by packing with flat sponges. If a perforation has taken place, and the contents of the stomach have passed into the peritoneal cavity, it generally happens, when the peritoneum is incised, that gas with clear or turbid fluid and particles of food escape.

The stomach having been found, search is made for the perforation. This, in most instances, is situated either on some part of the anterior surface of the viscus or in the vicinity of the lesser curvature and nearer the pyloric than the cardiac end. Often a welling up of fluid will point to the position of the aperture. If it cannot be at once seen, the stomach is palpated with the finger, and in many cases a localised hardness, or the presence of some flakes of fibrinous lymph upon the surface of the stomach, possibly causing adhesions to the inferior aspect of the liver, will indicate the region of the ulcer which has caused perforation. In order to examine the small curvature, it is necessary for the liver to be lifted up by the assistant. As the liver is lifted up, adhesions between its inferior surface and the stomach may become manifest. The presence of adhesions of this kind usually indicates the seat of the perforation. If the perforation cannot be discovered on the anterior aspect, or in the region of the small curvature, it will be necessary carefully to break through the hepato-gastric ligament (small omentum) on the left side of the portal vessels, and then examine the posterior aspect. A similar examination may be made by dividing the anterior two layers of the great omentum about ½ inch below the greater curvature. This, in my opinion, is a better method.

Occasionally, when the perforation is on the posterior aspect of the viscus, its position may be located by passing the finger through the epiploic foramen (foramen of Winslow) into the cavity of the bursa omentalis (lesser sac), and then palpating the posterior part of the organ.

When the perforation has been located by one of these methods, it must, if possible, be closed. Before doing this the region of the perforation must be "carefully sponged" with normal saline solution, so as to remove all stomach contents which may have escaped. If the aperture in the stomach wall is large a tube may be passed through it, and all food washed out from the interior of the stomach by irrigation.

(*c*) *Closure of perforation.*—The aperture is then closed by the insertion of a number of Lembert's sutures, each suture taking up the submucous, muscular, and serous coats only. If possible, that portion of the stomach which is the seat of the perforation should be brought into the parietal wound during the insertion of the sutures. All the sutures should be introduced before any are tied.

It is important to remember that the size of the perforation does not correspond with the size of the ulcer, and that, therefore, in order to avoid diseased tissue, the sutures must be placed at least ½ to ¾ of an inch clear of the margin of the aperture.

If the margins of the ulcer are indurated and irregular, it may be advisable to excise the hardened portion before introducing the sutures. In this case the margins of the opening are united first by a continuous suture, and then a second tier of sutures is introduced as above. Care must be taken that each Lembert's suture takes up some of the submucous coat.

The sutures are now tied, their ends cut short, and the region of the perforation well sponged. The stomach is then dropped back into the peritoneal cavity. Occasionally it will be found impossible to close the aperture with sutures. In some of these cases it may be possible to close the opening by stitching over it a piece of great omentum. When this cannot be done, the margins of the perforation must be sewn to the parietal incision, so as to make a gastric fistula; or, failing this, a drainage tube must be passed down to the perforation, and the part of the peritoneal cavity around the tube packed with long strips of gauze, one extremity of each strip protruding from the external incision.

(*d*) "*Treatment*" *of peritoneal cavity.*—When the aperture in the stomach wall has been dealt with by one of the methods mentioned above, the flat gauze pads or sponges are removed from the peritoneum, and the field of operation sponged dry. If there has been a general escape of stomach contents into the peritoneum, it will usually be advisable thoroughly to irrigate the peritoneal cavity with warm saline solution. Care must be taken to remove all débris from the pelvis, and in order to do this it may be necessary either to enlarge the incision in the abdominal wall, or to make a second one a short distance above the symphysis pubis. If the stomach contents have only contaminated the region of the perforation, it is not necessary to sponge or irrigate the general peritoneum.

When twelve or more hours have elapsed after perforation and before operation, and the general peritoneal cavity is infected, a second incision should be made in the hypogastrium, and the entire peritoneal cavity irrigated with hot normal saline solution (105°–110° F.), the irrigation being continued until the fluid returns quite clear. This having been done, the upper incision is closed by sutures in the usual manner, and a large drainage tube packed with gauze passed from the lower incision to the bottom of the pelvis and fixed in the lower angle of the wound, the remaining part being sutured. If a drainage tube is passed to the bottom of the pelvis through the lower wound and the general peritoneal cavity has been irrigated, it is essential that the patient be placed in the semi-recumbent or almost sitting position for a few days after operation. This position favours the passage of all fluids to the drainage tube, and hence to the exterior. In some cases it is also an advantage to make an incision in the lumbar region, especially the right, and establish lumbar drainage.

(*e*) *Establishment of drainage and closure of external wound.*—It is unnecessary, in many cases of perforation of a gastric ulcer, to drain the peritoneal cavity after the perforation has been closed. If, however, the general peritoneal cavity has been infected, it is treated as above mentioned by irrigation and pelvic drainage; but when only a limited area of the peritoneum has been contaminated, it is sufficient to pack this area with a broad strip of gauze, one end of which is brought out through a portion of the parietal wound left unsutured for the purpose, after carefully sponging the soiled parts; otherwise the external wound is closed by the insertion of tiers of sutures in the usual manner.

After-treatment.—It is necessary to combat shock by the administration of rectal salines, to minimise vomiting and neutralise gastric juice by carefully regulated feeds, and to relieve flatulence by such remedies as turpentine enemata. The following table should serve as a guide to the nursing treatment of an uncomplicated case of gastro-enterostomy :—

First Day (=day of operation).		
	Distilled water, ʒij, hrly., as required.	
10 P.M.	Whey, ʒiv, hrly.	
	Rectal saline, ℥x, 4-hrly.	
Second Day.	En. Tereb., mane.	
10 A.M.	Whey, ℥i	Alt. hrly.
	Milk extract, ℥i	
2 P.M.	Whey, ℥ij	Alt. hrly.
	Milk extract, ℥ij	
8 P.M.	Whey, ℥iij	Alt. 2-hrly.
	Milk extract, ℥iij	
	Rectal salines, ℥x, 6-hrly.	
Third Day.		
10 A.M.	Beaten egg and milk, ʒiij	Alt. 2-hrly.
	Milk extract, ℥iij	
	Jelly at dinner and supper.	
	Aperient may be given. Omit salines.	
Fourth Day.	En. Sap., mane.	
Breakfast.	Cocoa, ℥iv.	
Dinner.	Jelly and boiled custard.	
Supper.	Chicken broth or consommé, ℥iv.	
	Beaten eggs and milk, ℥iv	Alt. 2-hrly.
	Milk extract, ℥iv	
Fifth Day.		
Breakfast.	Cocoa, lightly boiled egg, rusks (2).	
Dinner.	Pounded fish, baked custard.	
Tea-time.	Cocoa (or China tea), egg, rusks (2).	
Supper.	Chicken broth, ℥v, jelly.	
	Extra feeds of milk or milk extract, ℥v, at 11 a.m., 3 and 9 p.m.	
	Aperient given at 3 p.m.	
Sixth Day.		
Breakfast.	Cocoa, egg, thin bread and butter.	
Dinner.	Pounded chicken, baked custard.	
Tea-time.	Cocoa (or China tea), egg, thin bread and butter.	
Supper.	Pounded fish, jelly.	
	Extra feeds of milk, ℥vj, at 11 a.m., 3 and 9 p.m.	

The toilet of the mouth must be performed at frequent intervals by swabbing out with sodium bicarbonate solution and washing with listerine. After operations for general peritonitis patients should be nursed in the semi-sitting position.

OPERATIONS UPON THE SMALL INTESTINE

Closure of perforating wounds.—Perforating wounds of the small intestine may be made—(*a*) By the surgeon, as in the removal of an impacted gallstone or a foreign body; or for the relief of flatus, during an abdominal operation, when distended coils of gut hamper the proceedings or prevent the return of intestine into the abdomen; or (*b*) as the result of an injury, such as stab with a knife, a fall upon sharp railings, a gunshot wound, or a bayonet wound.

The wound may penetrate either the abdominal parietes or the thoracic wall and the diaphragm.

In order to locate the position of the perforation of the intestine, it is usually necessary to perform an abdominal section, either through the linea alba or by enlargement of the original wound. It occasionally happens that a coil of intestine is protruded through the aperture in the parietes, and the perforation in it can be at once seen.

It is nearly always necessary in these cases, however, to examine the other coils of intestine, so as to be certain that a second perforation is not allowed to pass undetected.

When the wound has been discovered the injured loop of intestine is brought through the parietal incision, and surrounded with warm sponges or towels, and the region of perforation well washed, so as to remove all dirt or intestinal contents. Often the mucous membrane will be found to be protruded through the aperture in the intestinal wall. An attempt should be made in every case to unite the margins of the mucous membrane with a continuous fine suture of chromicised catgut. The perforation is again sponged clean, and the margins of the aperture in the muscular and serous coats approximated and fixed in apposition by a series of Lembert's sutures of fine silk, or celloidin thread, introduced about $\frac{1}{6}$ or $\frac{1}{8}$ inch apart, or by a continuous suture of similar material with occasional interruptions. Care must be taken in the insertion of these sutures that one is placed beyond each extremity of the aperture in the intestinal wall. If other perforations are present, they must be treated in a similar manner.

When all have been closed, the area of perforation is "sponged" with normal saline solution, the injured coil or coils returned into the peritoneal cavity, and the wound in the parietes closed in the ordinary manner.

The after-treatment of these cases is similar to that mentioned in connection with "resection of the intestine" (p. 127).

When the perforations are very large or numerous, it is usually necessary to remove the injured coil or coils according to the method which is described later.

Removal of a portion of intestine.—Removal of a portion of the small intestine is generally called "enterectomy," of the large intestine "colectomy."

Indications.—Excision, resection, or removal of a portion of the intestines is indicated in the following conditions, namely :—

(*a*) *Strictures.*—Strictures of the intestine, either simple or malignant, especially the latter. Simple growths of the intestines rarely cause obstruction which necessitates resection of the affected part, but occasionally such a procedure is called for. Malignant growths usually involve the large intestine, and when they are localised, and there are no signs of secondary affections elsewhere, resection is indicated.

(*b*) *Gangrene of intestine.*—Gangrene of a portion of the intestine is usually due to some form of strangulated hernia; removal of the gangrenous portion is then necessary. The method of treatment, after the dead portion has been removed, depends upon the situation of the diseased tissue, and the general condition of the patient. If the strength of the patient is good, or if the gangrenous portion is situated high up in the small intestine, anastomosis of the divided ends must be performed; whilst, if the condition of the patient is so serious that it is probable that a prolonged and severe operation will not be borne, the dead portion is removed and the open extremities of the divided gut fixed in the abdominal wound. If the patient survive this stage, the anastomosis and restoration of the canal can be effected at a later period.

(*c*) *Intussusception.* — Certain cases of intussusception in which the invaginated portion cannot be reduced, or gangrene has taken place.

(*d*) *Injuries.* — Those forms of injury to the intestines where extensive laceration of the walls of the gut has taken place.

(*e*) *Tuberculosis.* — Some forms of intestinal tuberculosis, when the affection is localised to one portion of the alimentary tract, as in tuberculosis of the cæcum.

(*f*) *Adhesions.*—Occasional cases of fibrous stricture following an injury, or due to extensive and tight adhesions.

(*g*) *Fistulæ.*—Intestinal fistulæ which are not curable by less severe methods.

(*h*) *Thrombosis of mesenteric vessels.*—Occasionally thrombosis of branches of the mesenteric arteries or veins, which is limited in extent and has caused gangrene of the gut, is amenable to treatment by excision.

Varieties of operation.—A number of different methods of resection of a portion of the alimentary canal have been adopted by surgical operators. The most important may be divided into two distinct classes, namely:—

(*a*) Methods in which the approximation of the divided extremities is accomplished by means of some form of *suture.* Two forms of this operation will be described—(1) Union by closure of divided ends and establishment of lateral anastomosis. (2) Union by *circular enterorrhaphy.*

(*b*) Methods in which the approximation is accomplished with the aid of a *mechanical appliance,* such as a *Murphy's anastomosis button,* a *bone tube,* or a *bone bobbin.*

These methods of union are available in what is called "end-to-end" anastomosis, but they have now been generally discarded owing to the fact that better results are obtainable by one or other of the suture methods.

Special instruments.—Scalpel with a long narrow blade like a finger knife, and intestinal clamps.

Position.—The patient in nearly all cases is placed in the dorsal position, but the position of the operator depends upon the situation of the parietal incision. The chief assistant stands directly opposite the surgeon, and the second assistant on his left hand.

Operation.—In all cases of resection of the intestine the actual operation may be divided into five stages, which are the following:—(*a*) Parietal incision; (*b*) finding the diseased portion of intestine, and bringing it out through the wound in the abdominal wall; (*c*) removal of the affected piece; (*d*) union of the divided ends of the intestine; (*e*) closure of the external wound. The first two and the last stages are similar in all forms of intestinal resection, but stages (*c*) and (*d*) differ in detail, according to the individual procedure which is being adopted. The first two stages (*a*) and (*b*) will be first described, then the modifications which occur in stages (*c*) and (*d*), and finally the method of closure of the external wound.

Choice of method of operation.—An extended experience of the different methods of intestinal anastomosis has convinced me that the best results are obtainable after closure of the divided ends and the establishment of a lateral anastomosis immediately beyond. Many surgeons have in the past used a "metallic button," a "bone bobbin," or "bone tube" as an aid in performing intestinal anastomosis, but at the present time these mechanical aids have generally fallen into disuse.

(*a*) *Parietal incision.*—The situation of the incision in the parietes depends upon the locality of the tumour or the part of the intestine which it is intended to remove. As far as possible, it ought to be made ½ inch to one side or other of the linea alba, or directly over the tumour. In the case of a strangulated hernia, it is not possible to decide whether the gut will require resection until it has been exposed through the usual hernial incision; and when it is found to be gangrenous the incision is enlarged sufficiently to enable the coil of gut to be brought out of the wound, and to allow of its return after the resection has been performed. Usually an incision from 3 to 4 inches in length will be long enough to enable the surgeon readily to perform all the manipulative procedures which are requisite.

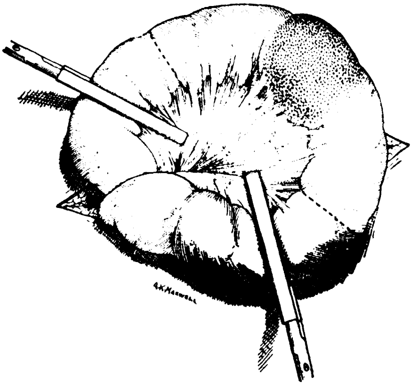

FIG. 109.—Enterectomy. Lines of incision in bowel and mesentery.

(*b*) *Finding the diseased portion of intestine, and bringing it out through the wound in the abdominal wall.*—The fingers of the right hand are introduced into the peritoneal cavity, the margins of the parietal wound being held well apart by retractors, and the affected portion of gut is sought for; when found, it is brought out through the external wound and surrounded with large flat sponges which have been wrung out of a warm saline solution. If there are any adhesions which hold down the affected coil or loop, they are either broken down with the fingers or they are tied in two places with silk ligatures and divided. The intestine having been delivered in this manner, the contents are forced onwards with the fingers until the lumen of the affected part is quite empty. Two intestinal clamps are taken and applied to the intestine, 2 to 3 inches above and below the lines where it is intended to make the section. If these clamps are placed too near the lines of section they interfere with the insertion of the sutures, and with the application of measures which have for their object the asepticity of the area of operation.

In cases of malignant disease it is necessary to examine the mesentery for enlarged lymph glands, which, if found, must be removed along with the portion of mesentery in which they are located.

(*c*) *Removal of the affected piece.*—The intestinal tube is divided transversely to its long axis, and well beyond the diseased tissue. This can be done either with strong scissors, or by transfixing the mesentery close to the intestine with a long narrow-bladed scalpel, and cutting outwards. When this has been done, the portion of mesentery which is attached to the separated piece of intestine is divided along the line of attachment of the gut (Fig. 109) when possible; but if the adjacent portion of mesentery is diseased, gangrenous, or infiltrated with new growth, a wedge-shaped piece must be taken away, the line of section being made through sound tissues (Fig. 110). As this is done hæmorrhage from many small blood vessels occurs, and is arrested by picking up each bleeding point with a pair of pressure forceps.

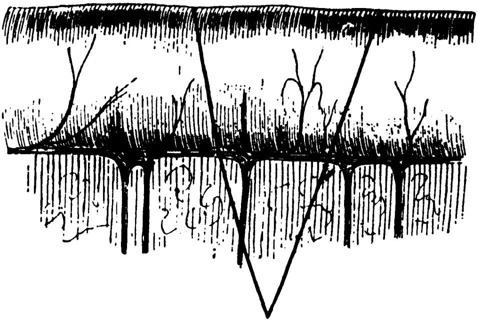

FIG. 110.—Enterectomy. Lines of incision in bowel and mesentery, when a V-shaped piece is removed from the latter.

The advantage of the former method of division of the mesentery is that a better blood supply is left than when a wedge-shaped piece is removed. When all hæmorrhage has been arrested, and the cut ends of the intestine well washed with normal saline solution, approximation and union can be performed.

End-to-end anastomosis.—*Union of the divided intestine —By circular enterorrhaphy.*—The cut ends of the bowel

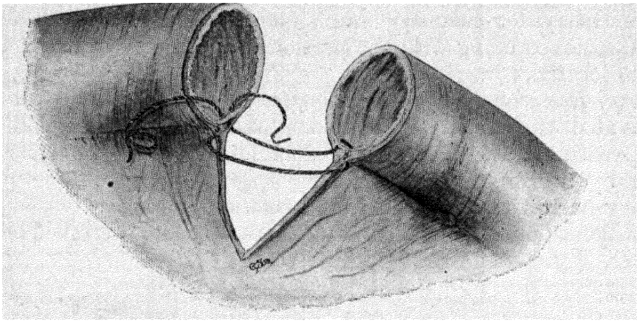

FIG. 111.—Enterectomy. Segment of intestine and mesentery have been removed ; and " mattress " suture inserted but not tied.

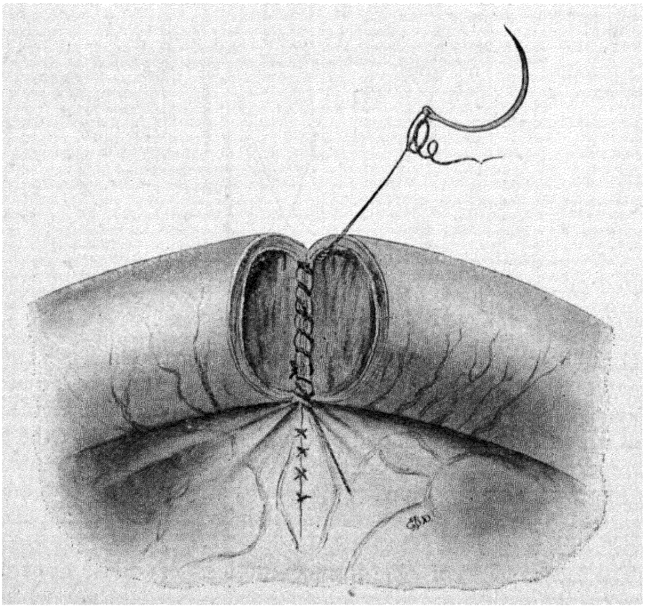

FIG. 112.—Enterectomy. Showing method of insertion of continuous suture, uniting cut margins of two ends of intestine.

being held near together by an assistant, a " mattress " suture of No. 1 chromicised catgut is introduced in the manner depicted in Fig. 111. The needle first pierces the mucous membrane and intestinal wall about ⅛ inch from the cut margin, passes through the triangular intermesenteric space (Fig. 111), and emerges through the peritoneum of the mesentery opposite the lower part of this triangular space. Next it is made to transfix the wall of the other segment of intestine in the opposite direction, commencing on the peritoneal aspect of the mesentery, and finally to return by piercing the walls of the intestine as before. This suture is now tied, care being taken to prevent infolding of the mucous membrane, and the ends cut short. A continuous suture of chromicised catgut, with several knots or interruptions, piercing all the coats of the bowel, is next inserted. A commencement is made, ½ inch on the proximal side of the mesenteric suture, by passing the needle through the walls of the intestine so as to leave the first knot on

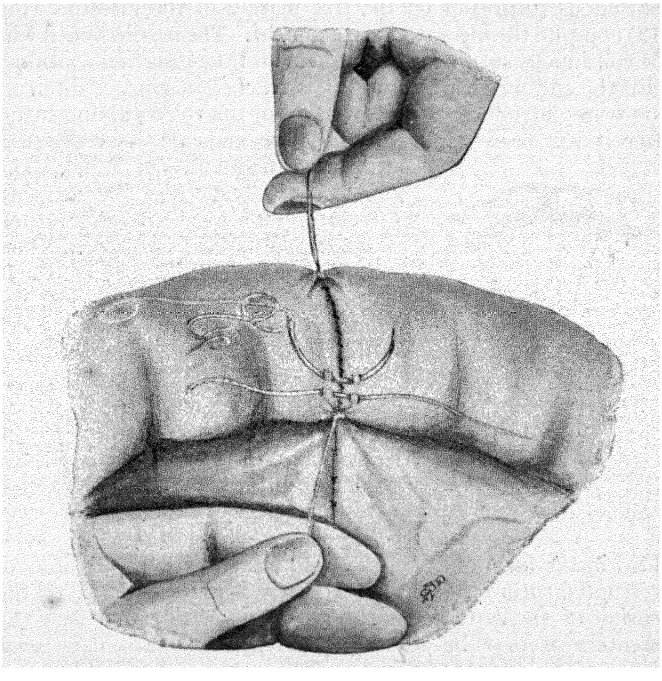

FIG. 113.—Enterectomy. The two ends of divided intestine have been united by a continuous suture; and the second tier of sutures are being inserted by Lembert's method.

the outside, and one end of the suture long, as a guide. A second guide is next passed at an equal distance on the opposite side of the mesenteric margin and the two given to an assistant, who holds them taut, whilst the continuous suture is inserted. When the second guide is reached the continuous suture is tied, and the guiding suture taken out, a further guide being put in half-way between the one removed and the long end of the continuous suture, or on the free margin of the intestine (Fig. 112) opposite the mesenteric attachment. The needle armed with the continuous suture is again taken, and the insertion continued until the end which was left long is reached, a knot or interruption being introduced at the position of the third guiding suture after it has been removed. The two ends of the continuous suture are tied and cut short. This completes the first " tier " of suturing.

A second tier of Lembert's sutures of silk No. 0 is now inserted. These commence at the mesenteric attachment and the free convex border, and are placed about $\frac{1}{8}$ inch apart. Each suture pierces the serous and muscular coats and picks up a little of the submucous layer (Fig. 113). When all these sutures have been introduced and tied, the margins of the V-shaped space in the mesentery are sutured together, or if it has been possible to preserve the mesentery, as in Fig. 109, it is folded in the form of a " pleat " and united with a few points of interrupted suture (Fig. 114). If there is any doubt as to the security of the stitches in the part of the intestine near the mesentery, it may be advisable to stitch the mesentery over this portion, in order to give a little extra security. In most cases, however, this is not requisite. The line of approximation of the two ends of intestine is now carefully washed, together with any soiled portion of the peritoneum, the clamps are removed, and the gut returned into the peritoneal cavity.

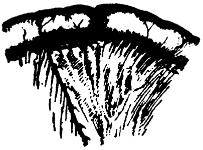

FIG. 114.—Enterectomy. Appearance of intestine when the operation is completed. The mesentery opposite the resected portion is folded upon itself, and fixed by a few points of suture.

Lateral anastomosis.—In this operation two loops of intestine are fixed in apposition in such a manner that the convexities of the coils are close together. This form of operation is recommended after incision of a portion of intestines in preference to end-to-end anastomosis, since better permanent results follow, and also when a patient suffers from an obstruction in the course of the alimentary canal which is not removable by a radical operation, but it is desirable to side track the contents of the canal and so avoid the development of acute obstruction. This operation is also recommended in some cases of intestinal obstruction, when owing to the serious condition of the patient a severe operation is not considered desirable. If the patient survives, then the more severe procedure of removal of the obstruction, whether new growth or stricture, can be carried out later, and with a much increased prospect of success.

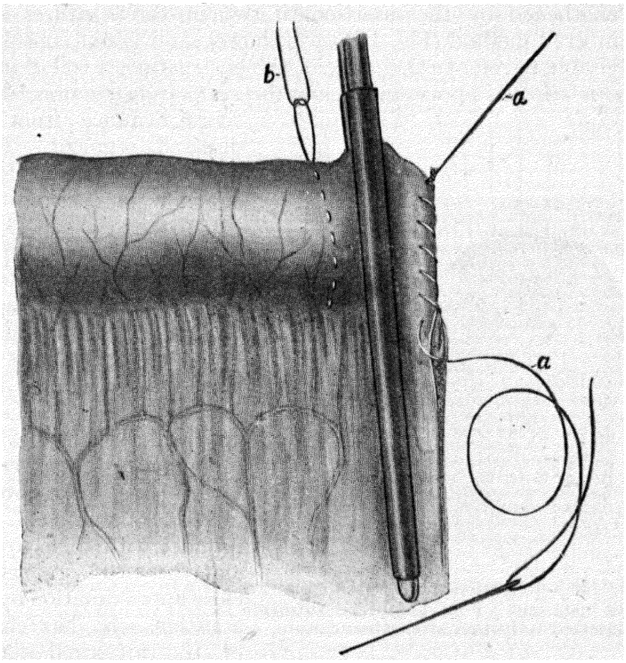

FIG. 115.—Resection of intestine. Closure of open end.

a. Through-and-through suture which first closes open end.
b. Purse-string suture on proximal side of clamp, which securely closes open end.

This procedure is adopted chiefly for the relief of those cases of stenosis of the gut unsuitable for direct treatment by removal of the cause of stricture or obstruction.

The abdomen having been opened by a median or other incision, the seat of obstruction in the alimentary canal is sought for. When there are no signs of acute obstruction, and it is decided to remove the diseased or affected segment, this is done as described in the preceding paragraphs. The cut ends proximal and distal are closed by the method shown in Figs. 115 and 116. First the open extremity is closed by a continuous suture of catgut (Fig. 115). Next a purse-string suture is inserted on the side proximal to the intestinal clamp, the clamp is removed and the suture tied. Next the closure is strengthened by the insertion of two or three sutures after Lembert's method (Fig. 116). If, however, it is not considered advisable to remove the cause of the obstruction, a coil of intestine is selected above and below the seat of obstruction, and a short distance from the diseased segment. Each loop is emptied of its contents, by passing it between the fingers. Intestinal clamps are applied to the upper and lower extremities of each loop, as in "intestinal resection," or an intestinal clamp with long blades applied in a manner similar to that in applying a clamp to the jejunum in gastro-enterostomy. The exposed intestines are well surrounded with warm towels, and the two loops held in close approximation by the assistant who has charge of the intestinal clamps (Fig. 117). A continuous suture of silk No. 1, or celloidin thread with a few interruptions, is introduced in the form of one side of an ellipse for an extent of about 3 inches (Fig. 117, *a*), commencing on the adjacent parts of the loops of intestine, the extremity is knotted, and the needle laid aside still threaded. This line of suture fixes the two loops of intestine together. Next an incision 2 inches long is made on the convexity of each loop of the bowel opposite the mesenteric attachment (Fig. 117, dotted line). This incision is situated about ¼ inch distant from and lies parallel with the median portion of the previous line of suture. The interior of each loop of intestine is cleaned out by careful sponging.

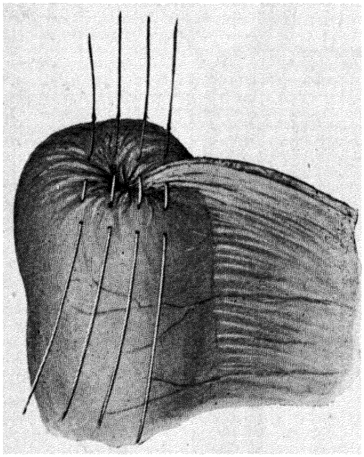

FIG. 116.—Resection of intestine. Closure of open end. Four Lembert's sutures inserted to further strengthen closure.

The margins of the apertures are then sewn together by a continuous suture of No. 2 chromicised catgut (Fig. 118, *c*) with several knots or interruptions, and the two ends finally tied together, this suture being passed through the entire thickness of the intestinal walls. The parts are next carefully sponged, the intestinal clamps removed, the needle threaded with silk taken up, and the insertion of the elliptical sero-muscular suture continued until the point of commencement has been reached, when the two ends are knotted together and cut short.

The anastomosis being now completed, the protecting sponges are taken away and, after sponging the exposed peritoneal areas, the loops of intestine are returned into the abdominal cavity, and the parietal wound closed by the insertion of three tiers of sutures in the usual manner.

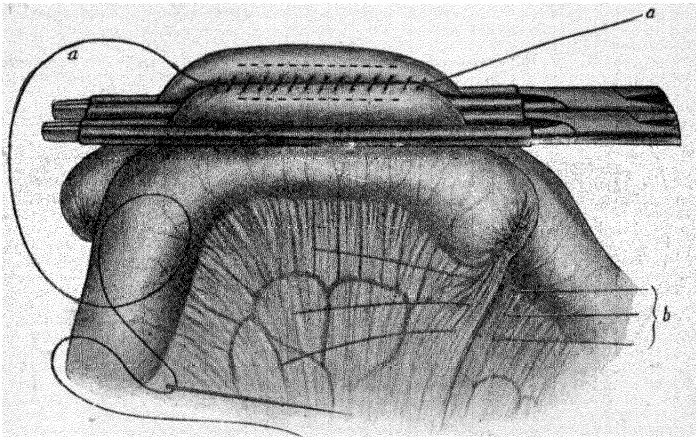

FIG. 117.—Lateral intestinal anastomosis. Two segments of gut approximated.

a. Sero-muscular suture. *b.* Sutures closing mesentery opening.

After-treatment.—The first essential of treatment after resection of gut is to prevent stasis, putrefaction of the intestinal contents and consequent toxæmia. Peristaltic movements are stimulated by the subcutaneous injection of liq. strychninæ ♏ vij and esserine sulphate (or salicylate) gr. $\frac{1}{100}$ every four hours. Small repeated doses of calomel (*e.g.* gr. ½ half-hourly up to grs. vj) act as a powerful intestinal antiseptic and evacuant. Rectal salines half to one pint three-hourly or given by the continuous drip method, are of great value in combating shock and in the elimination of toxins. Should there be distension a turpentine or oxgall enema should be given. Food should be light, sustaining, and of a nature that will not leave much residue. The feeds should be small and frequent.

Formation of an artificial anus or creation of an intestinal fistula.—It only rarely happens that it is necessary to establish an artificial communication between the lumen of the small intestine and the surface of the body.

Indications.—(*a*) Acute intestinal obstruction of some part of the small intestine, which cannot otherwise be relieved.

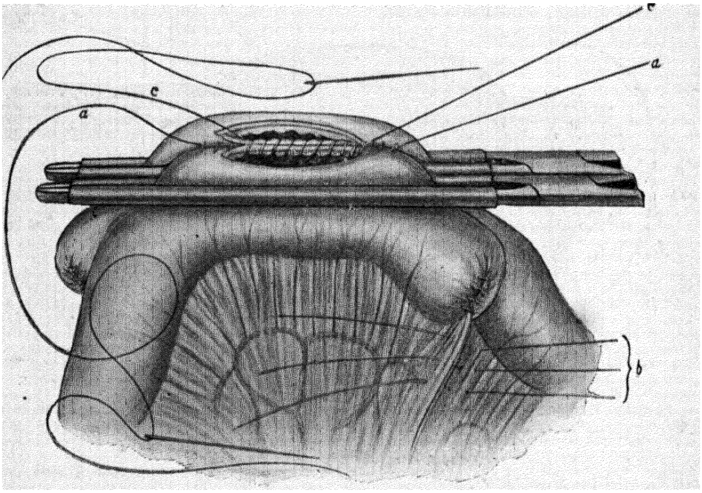

FIG. 118.—Lateral intestinal anastomosis.

a. Sero-muscular suture partially inserted, anastomosis has been established.
b. Sutures closing defect in mesentery.
c. Suture through-and-through, establishing anastomosis.

(*b*) Strangulated hernia, in which the herniated portion of gut has become gangrenous, and the condition of the patient will not allow of the performance of an intestinal anastomosis.

Special instruments.—Trocar and cannula, or aspirator, and needles.

Position.—The patient is placed in the dorsal position on the operation table, while the operator stands on whichever side is the more convenient, and the assistant stands opposite to him.

Operation.—In cases of strangulated hernia, the incision will necessarily be made in one of the hernial regions, and in other cases of intestinal obstruction it will usually be made near the linea alba or the linea semilunaris, according to the supposed position of the obstruction.

The loop of intestine which it is proposed to open is brought into the parietal wound, and is fixed to the margins of this by the insertion of a series of sutures, each suture passing through the serous, muscular, and submucous coats of the intestine, and then through the serous, fascial, and cutaneous strata of the abdominal wall. In practice it will usually be found advisable to open the intestine and allow the escape of the fluid or gas with which it is distended, before an attempt is made to attach it to the abdominal wall; or, in the case of gangrene, it may be requisite to remove the dead portion before this is done. The exact method of inserting the sutures is described in connection with "Inguinal Colostomy" (p. 148).

Perforated duodenal ulcer.—In the majority of instances the operation requisite for the treatment of a perforated duodenal ulcer is similar to the procedure which has been described in detail in connection with "perforated gastic ulcer" (p.113 *et seq.*). When a definite diagnosis of perforation of a duodenal ulcer has been made, the abdomen should be opened by an incision 3 to 4 inches long above the umbilicus, and about 1 inch to the right of the middle line. When the aperture of perforation has been located—it is usually in the commencement of the first part, rarely in the second or third—it is closed by sutures, as in the case of a similar ulcer of the stomach. It should be remembered that perforation may take place into the omental bursa (lesser sac), in which case an abscess will develop in this space, and may extend to the subphrenic region, forming a subphrenic abscess.

Perforated typhoid ulcer.—Perforation of a typhoid ulcer into the general peritoneal cavity gives rise either to septic peritonitis or to the development of a localised intra-peritoneal abscess. The former result is very much more frequent than the latter. During recent years many operations have been done for the closure of the perforation in the bowel wall, as well as the treatment of the resulting peritonitis. Personally, I have performed the operation nine times; three patients recovered and six died. A collection of the recent cases which have come under my observation shows that from 25 per cent. to 40 per cent. of cases recover, the higher percentage being obtained when the operation has been carried out within twelve hours from the time of occurrence of perforation.

Indications.—All cases in which perforation of a typhoid ulcer of the intestine has been diagnosed should be submitted to operation as soon as possible after the occurrence of the perforation. This operation has for its object, finding and closure of the perforation, and cleansing and drainage of the contaminated area of peritoneum.

Position.—The patient is placed in the dorsal position, the lower limbs being slightly drawn upwards by flexion at the knee and hip. The operator stands on the right side and the chief assistant on the left.

Operation.—The operation can be divided into four stages :—

(*a*) *Parietal incision and opening of peritoneal cavity.*—A vertical incision, which commences at the lower margin of the umbilicus and extends downwards for 3 inches, or even more if the abdominal walls are thick, is made a little to the right of the middle line. The different strata of the abdominal wall are cut through in the usual manner, and the peritoneal cavity opened.

(*b*) *Finding and closure of perforation in intestine.*—When the peritoneal cavity has been opened, the forefinger is passed inwards and the peritoneum on the right side of the incision carefully palpated, in order to detect if any adhesions between a coil of intestine and the abdominal wall are present. It occasionally happens that the intestine at the seat of perforation becomes adherent to the deep aspect of the anterior abdominal wall. I no adhesions are met with, the margins of the wound are strongly retracted, and the lower portion of the ileum is brough into the parietal wound and carefully examined, in order to locate the position of any perforation which may be present. I the lower part of the ileum does not show any perforation, the cæcum, vermiform process (appendix), and adjacent portion o the ascending colon are examined with the same object. Failing detection of an ulcer here, the iliac and pelvic portions of th colon are felt for in the left iliac fossa and pelvis, brought into th wound and examined. Practically all cases of perforation o ulcers of the intestine in typhoid fever have been found in th lower portion of the ileum, in the ileo-cæcal region, or in the ilia colon. When the perforation has been located it is closed by the insertion of a series of silk sutures by Lembert's method The line of sutures should be placed transversely to the long axi of the bowel. Care must be taken, in inserting the sutures, t place them beyond the margin of the perforated ulcer, and at th same time not to perforate a second ulcer in the immediate neighbourhood. The position of other ulcers can be distinguished as they are indicated by a discoloured area on the wall o the gut. If necessary, a second tier of sutures may be inserted when there is any doubt as regards the complete closure of th perforation. When this has been satisfactorily accomplished, the portions of intestine immediately above and below the region of the perforation are carefully examined, in order to detect the existence of a possible second perforation.

(*c*) *Treatment of peritoneal cavity.*—The region of the sutured intestine should be carefully sponged with warm saline solution, and all contaminated areas of peritoneum should be treated in a similar manner, special attention being given to the recto-vesical pouch. When more than twelve hours have elapsed after perforation and before operation, and the general peritoneal cavity is contaminated with the contents of the intestine and the exudation which has been so induced, irrigation of the abdomen with hot saline solution should be practised until the returning fluid comes out quite clear. If the patient is very collapsed at the end of the operation, it is advisable to leave a quantity of hot saline solution in the peritoneal cavity.

(*d*) *Partial closure of external wound and establishment of drainage.*—When there has been only slight contamination of the peritoneal cavity, and consequently limited peritonitis, a gauze drain should be passed down to the region of the sutured intestine, and the remainder of the wound in the abdominal parietes closed. If, however, a considerable area of the peritoneum has been contaminated by intestinal contents, or there is extensive peritonitis, a large rubber drainage tube, with a gauze packing in the interior, should be passed down to the bottom of the recto-vesical pouch (Douglas's pouch) or the right iliac fossa, or both, whichever happens to offer the best drainage. The other parts of the abdominal wound are closed by sutures.

In the after-treatment of those cases in which the peritoneal cavity has been irrigated on account of general peritonitis, and a large drainage tube passed to the bottom of the pelvis, the patient should be propped up in a semi-sitting posture for a few days so as to facilitate the passage of any fluid to the drainage tubes by gravitation.

OPERATIONS UPON THE LARGE INTESTINE

Removal of the vermiform process (vermiform appendix). The vermiform process (appendix) is attached to the postero-internal aspect of the cæcum, a short distance, usually about ½ inch, below the lower border of the ileo-cæcal valve. The length of the process varies considerably. It usually measures 3 or 4 inches, but in some cases it is not more than 2 inches long, whilst in others it may be even 10 inches. The position of the free extremity also varies : usually it hangs over the pelvic brim in front of the commencement of the external iliac vessels, and then has a distinct mesentery formed by a double fold of peritoneum, in which is a small artery, from the ileo-cæcal branch of the superior mesenteric artery. The corresponding vein is a tributary of the portal vein. In other cases the process is located behind some part of the cæcum and ascending colon, lying coiled up in the ileo-cæcal or sub-cæcal (retro-cæcal) pouches of peritoneum, or it may be situated in the iliac fossa immediately above the middle part of the inguinal ligament (Poupart's) of the right side.

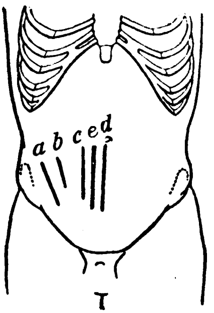

FIG. 119.—Removal of vermiform process (appendix). Position of patient and parietal incisions.

a. Incision for appendix abscess.
b. Incision for removal by "gridiron" incision.
c. Incision for removal by passing through sheath of rectus abdominis.
d. Incision for removal by median method.
e. Incision for removal by paramedial method.

Indications for removal.—Removal of the vermiform process (appendix) is indicated in the following circumstances, namely :—

(*a*) Acute appendicitis.

(*b*) Perforation of the process.

(*c*) Ulceration of the interior of the process, leading to a collection of pus within it, to localised destruction of its wall, and perforation.

(*d*) Cases of relapsing appendicitis, in which each successive attack is worse than the previous one, or in which serious inconvenience is caused.

(*e*) Those pathological conditions which necessitate removal of the cæcum.

Position.—The patient is placed in the dorsal posture, near the right edge of the table ; the surgeon stands on the right side, opposite the iliac region, and the assistant on the left.

Operation.—Removal of the process may be divided into three stages, namely :—

(*a*) *Parietal incision.*—An imaginary line is drawn from the anterior superior iliac spine of the right side to the umbilicus, and a point a third of the distance from the iliac spine selected. When there is reason to believe that many adhesions exist, the selected point should be half-way between the anterior superior iliac spine and the umbilicus. An incision 3 inches in length is made at right angles to the imaginary line, and passing through the selected point. One-third of this incision is above the line, and two-thirds below it. Care must be taken, however, not to prolong the lower limit of the incision as far as the inferior epigastric vessels. The skin and fasciæ are divided, and the aponeurosis of the external oblique muscle exposed. Next, this muscle is divided parallel with the direction of its fibres for the entire length of its exposed portion. This division is commenced with the scalpel and completed with the fingers. The margins of the incision in the external oblique are now held widely apart with retractors, so as fully to expose the fibres of the internal oblique muscle. These are separated and divided parallel with the direction of the fibres in a manner similar to that adopted for the external oblique. The line of division of the internal oblique is almost at right angles to that in the external oblique. Next, the fibres of the transversus abdominis (transversalis) are separated in a like fashion. They will be found to be practically parallel to those of the internal oblique. The margins of the apertures thus made in the muscu-

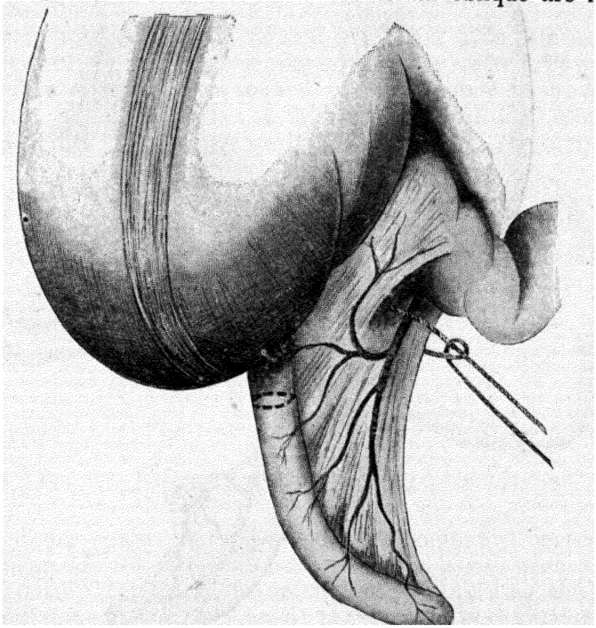

FIG. 120.—Removal of vermiform process. Line of incision through serous and fibrous coats, and ligature of mesentery of vermiform process.

lar strata are held widely apart with strong retractors, and then the transversus fascia and parietal peritoneum are divided in the line of the skin incision. The abdominal cavity is thus opened.

The advantage of opening the abdominal cavity in this manner is, that the patient is very much less liable to the development of a ventral hernia afterwards at the seat of the parietal incision, owing to the fact that little scar tissue is produced, very few muscular fibres are divided, and the incisions through the different planes of the abdominal wall are not opposite one another.

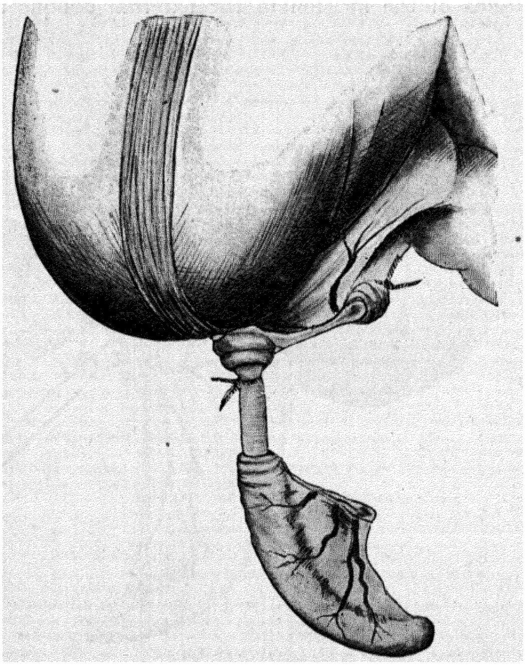

FIG. 121.—Removal of vermiform process (appendix). "Cuff" of serous and fibrous coats dissected back, and mucous coat ligatured close to its attachment to cæcum.

Operation by incision through the rectus sheath—An incision about 3 inches long is made over the lower segment of the right rectus and ½ an inch from its outer border, the upper end of the incision extending slightly above the umbilicus. After division of the skin and fasciæ, the anterior layer of the rectus sheath is divided in the line of the original incision. The outer border of the cut sheath is carefully dissected from the muscle, which is now retracted inwards. The nerves to this portion of the rectus muscle must now be identified. They will be found lying one just below the middle of the incision and another near the upper extremity. The nerves are carefully retracted up and down, and the posterior layer of the rectus sheath and the peritoneum are incised in the direction of the original incision.

Some surgeons make a vertical incision a little internal to the linea semilunaris. After exposure of the anterior layer of the rectus sheath this is incised and the muscle is retracted inwards. Next two nerves to the rectus are identified crossing the posterior layer of the sheath of the muscle; these are retracted, one upwards and one down. A longitudinal incision is made through the sheath and the peritoneal cavity opened.

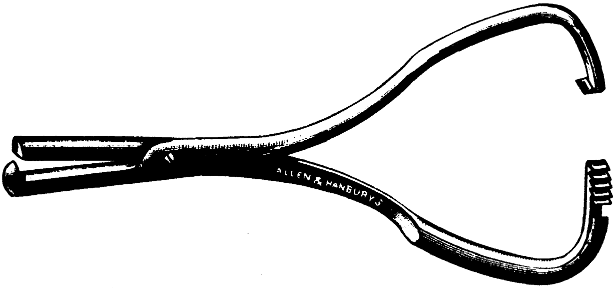

FIG. 122.—Clamp for crushing base of vermiform process.

Personally, I think the first method, muscle-splitting, the best, because there is less risk of danger to the nerves of the abdominal wall, and, in cases where suppuration has occurred, better drainage can be readily established, and there is less danger of secondary hæmorrhage owing to septic infection of the inferior epigastric (deep epigastric). When, however, there is some doubt concerning the diagnosis, a suppurative salpingitis (right), or disease of the right ovary suspected, the *paramedial incision* should be made use of; since the right ovary and Fallopian tube are more accessible and more easily dealt with by this route, whilst usually the vermiform process is easily accessible.

(*b*) *Finding, separation, and removal of vermiform process.*—The coils of the small intestine and the lower margin of the large omentum are pushed over towards the left, and kept there by packing with a large flat gauze sponge. If no adhesions are present the cæcum is lifted upwards and towards the right, and then the process (appendix) will be partially or entirely exposed. The process having been found in this way, its mesentery must be next defined. When this has been done the mesentery is transfixed at its base, close to the cæcum, with a needle armed with a silk ligature (Fig. 120). This ligature is tied, and the line of attachment of the mesentery to the process divided with a pair of scissors. By this means the process is freed from its connections, except where it is attached to the cæcum. The apex of the process (appendix) is seized with pressure forceps, and with the scalpel the serous and muscular (or fibrous) coats are divided in a circular manner, about ½ inch from the cæcum, and a " cuff " or " flaps " of tissue stripped back until the cæcum is reached (Fig. 121). Care must be taken not to divide the mucous membrane during this procedure. A fine silk ligature is then tied around the mucous membrane, just beyond its junction with the cæcum; the tube of mucous membrane immediately distal to the ligature is cut across with scissors, and the process removed. The ligature which surrounds the mucous membrane of the stump of the process (appendix) is cut short, the exposed mucous membrane cauterised with liquid carbolic acid and sponged dry. The stump of the appendix is

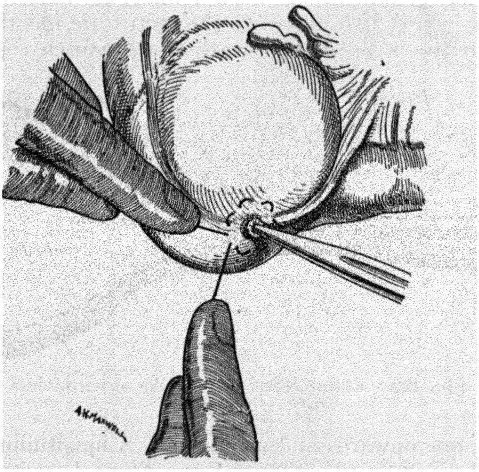

FIG. 123.—Removal of vermiform process (appendix). Insertion of sutures over stump of process.

invaginated into the cæcum and held by a purse-string suture of catgut.

If, owing to adhesions or inflammatory changes, it is not possible to dissect back a "cuff" of serous and fibrous coats, a silk ligature is applied around the entire process at its junction with the cæcum, and the structure removed. Next, the mucous membrane in the middle of the stump is cauterised or well washed with an antiseptic, and then the stump is inverted into the cæcum and held in that position by bringing the adjacent portions of the serous and muscular coats of the cæcum together, by means of two or three fine silk Lembert's sutures. Some surgeons prefer to crush the base of the process with an appendix clamp. Personally, I prefer the ligature method. Fig. 122 represents the form of clamp which can be used for this purpose.

(*c*) *Closure of the external incision.*—The region of operation is well washed with salt solution, especially where there has been any soiling of the peritoneum, the sponges are removed, and the external wound closed by the insertion of tiers of sutures, each layer of the abdominal wall being sewn up separately.

Suppurative appendicitis.—Two essentially different conditions, as regards the character of the surgical procedures to be adopted, are met with in cases of suppurative appendicitis. The first class of case comprises those patients in whom an attack of appendicitis has given rise to a localised abscess, which is generally limited to the lower portion of the right iliac fossa, in the region of the vermiform process (appendix). This abscess may either be a localised suppurative peritonitis around a diseased process, in which the adjacent portion of the peritoneum is cut off from the abscess by the development of a number of fibrinous adhesions; or it may be a collection of purulent matter behind the cæcum, vermiform process (appendix), and parietal peritoneum, and in the fascial layers of the right iliac fossa in front of the ilio-psoas muscle. Clinically it is not often possible, before commencing an operation, to make an exact diagnosis as to whether an individual case belongs to one or other of these varieties. The second class of case includes those patients in whom a suppurative appendicitis has given rise to perforation of the wall of the vermiform process (appendix), extension of the purulent contents to the general peritoneal cavity, and establishment of general suppurative peritonitis.

Indications for operation.—Whenever the symptoms and physical signs in a patient, presumed to be suffering from appendicitis, point either to the development of a localised abscess, or to the occurrence of perforation of the vermiform process (appendix), and establishment of general peritonitis in the region of the right iliac fossa and the pelvis, an operation should be carried out without delay. The object of this operation is to expose the abscess cavity, if present, evacuate its contents and establish free drainage, so as to avoid, as far as possible, extension of the suppurative process to other parts of the peritoneum or adjacent abdominal viscera, and if possible to remove the diseased process (appendix). When the general peritoneum has been invaded, the region of the vermiform process (appendix) and its associated abscess in the right iliac fossa must be exposed and dealt with, and then the parts of the peritoneum which have been invaded, freed from purulent matter and efficiently drained. In all cases the vermiform process (appendix) should, if possible, be removed. In the latter class of case it is often necessary to make a second incision at or near the middle line, or in the right lumbar region, in order satisfactorily to evacuate all the purulent collection and thoroughly drain the contaminated areas.

Operation.—The operation may be divided into several stages :—

(*a*) *External incision and division of abdominal wall.*—Before deciding upon the exact line of incision, the region of the right iliac fossa should be carefully palpated, in order to locate the position of the abscess, and also any point where it may be adherent to the deep aspect of the anterior abdominal wall. If adhesions, or any specially prominent fluctuating area, can be made out in this manner, the incision should be made directly over them. In other cases, an incision 2½ to 3 inches long is made, parallel with and about two-thirds of an inch above the outer half of the inguinal ligament (Poupart's) and the anterior portion of the iliac crest. The different strata of the abdominal wall are successively divided, the muscles in a line parallel with the direction of their fibres, until the extra-peritoneal layer is exposed. This can usually be recognised, in suppurative cases, by its œdematous condition or the presence of flakes of fibrinous lymph. An ascending branch of the deep circumflex iliac artery will usually be cut, as it lies between the internal oblique and the transversus (transversalis). When cut, this vessel should be at once ligatured, as it bleeds freely, and so prevents a free view of the area of operation.

(*b*) *Opening and evacuation of the abscess cavity and its connections.*—When the extra-peritoneal tissue has been laid bare the bottom of the wound is carefully examined with the forefinger, in order to detect the exact locality of the purulent collection. If it lies underneath the exposed area the parietal peritoneum should be carefully incised so as to avoid opening the cæcum, in those cases in which this viscus is attached to the deep aspect of the anterior abdominal wall by fibrinous adhesions. The abscess cavity can often be opened by carefully scratching away the fibrinous lymph and sodden and œdematous peritoneum with a probe-pointed director. When the abscess cavity appears to be behind the peritoneum and in the fascial layers of the iliac fossa behind the cæcum, the parietal peritoneum should be separated by careful dissection from the fascia transversalis and iliac fascia, until the abscess can be opened without laying bare the general peritoneal cavity. The cavity having been opened by one of these methods, its contents are evacuated and its interior thoroughly exposed to view by well retracting the margins of the external wound. Its walls are sponged dry, and any local prolongations or connections opened up by the finger, and their contents evacuated. Care must be taken during these manipulations and investigations, that adhesions which may be present, and shutting off the abscess cavity from the general peritoneal cavity, are not broken down or separated. When no adhesions exist, the contents of the abdomen, such as coils of small intestine or portions of the large omentum, are carefully protected by flat sponges or cellular pads. The majority of localised appendicular abscesses in the right iliac fossa have prolongations into the adjacent part of the pelvis; and in those cases in which suppuration is not localised, the bottom of the recto-vesical pouch (Douglas's) will almost always be found to contain a collection of purulent matter. Hence, in dealing with these cases, especial attention must be directed to the condition of affairs in the right side and bottom of the pelvis.

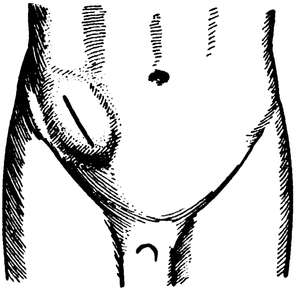

FIG. 124.—Position of incision in suppurative appendicitis causing a localised abscess.

(*c*) *Treatment of the vermiform process* (*appendix*).—When the vermiform process is seen lying at the bottom of the abscess cavity, and is readily removable, this should always be done, provided the removal can be carried out without opening up the general peritoneal cavity, and causing infection of the peritoneum. When it is firmly bound down to adjacent structures by adhesions, and it is thought that removal will involve opening up and infection of the general peritoneum, it is better not to attempt it, but to wait until a more favourable period. It is not possible, however, to lay down exact laws on this point, as each individual case requires to be judged on its merits. Whenever the abscess cavity communicates with the peritoneum, and is not shut off by adhesions, then in all these cases the vermiform process (appendix) — the actual cause of infection of the peritoneum—must be sought for and removed. When found, the process is separated from its surroundings by breaking down or cutting through adhesions until its attachment to the cæcum is exposed, the mesentery of the process being transfixed and ligatured if necessary. The actual separation of the process from the cæcum is similar to that described on page 135. When the process (appendix) is removed from the bottom of an abscess cavity, it is sufficient to separate it from its surroundings, encircle its base with a ligature of chromicised catgut, and cut away everything distal to the point of application of the ligature.

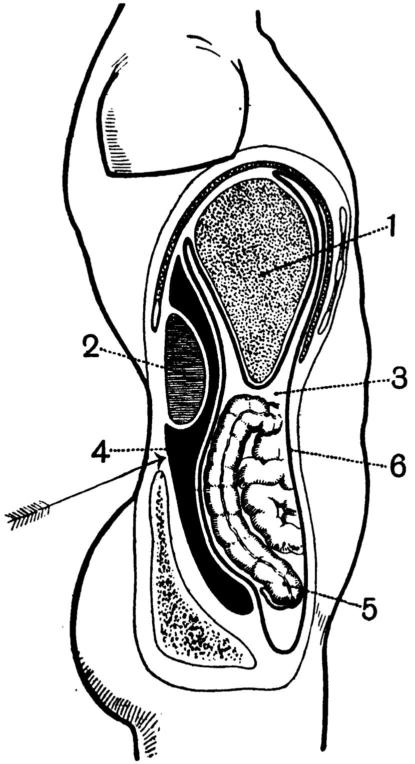

FIG. 125.—Sagittal section through the middle of the right iliac fossa, illustrating the method of extension upwards of an appendicular abscess.

1. Liver. 2. Right kidney.
3. Peritoneal cavity. 4. Appendix abscess.
5. Cæcum and vermiform process.
6. Parietal peritoneum.

(*d*) *Treatment of the adjacent peritoneum.*—In those cases in which the suppurative affection of the vermiform process (appendix) has given rise to a localised peritonitis within the right iliac fossa, and when this is cut off from the general peritoneal cavity by the establishment of adhesions, the cavity should be thoroughly drained by the insertion of one or two moderately large rubber drainage tubes, in which holes have been cut in the parts which actually lie within the abscess cavity. When there are prolongations into the adjacent portion of the pelvis, or upwards into the upper part of the iliac fossa, rubber drainage tubes must be passed to the limits of the suppuration area. If there are no adhesions, and general peritonitis has been established, after evacuation of all purulent fluid, the infected areas should be sponged dry as far as possible, and then irrigation with hot salt solution practised, and rubber drainage tubes inserted, one into the iliac fossa and the region from which the vermiform process (appendix) has been removed, and one to the bottom of the recto-vesical pouch (Douglas's).

Often an appendicular abscess spreads upwards towards the loins and forms either a perinephric or subphrenic abscess. Fig. 125 illustrates the method of spread in this manner. When extension upward occurs, a counter-incision should be made in the loin, in the position indicated by the arrow in the illustration.

When the patient is much collapsed after an operation of this kind, and there is extensive infection of the peritoneum, it is advisable to irrigate the general peritoneal cavity with hot saline solution, and to leave a quantity of this fluid in the space.

(*e*) *Closure of external wound.*—Only the extremities of the external wound should be closed by sutures, the remainder being left open for the exit of the drainage tubes and for insertion of any gauze packing which may happen to be requisite. It will occasionally be found necessary, in the latter class of cases, to make a second incision in the abdominal wall. This is generally made in the middle line and below the umbilicus. It allows the surgeon to deal more readily and effectively with suppurative affections within the pelvic cavity, and to establish better drainage from these areas.

Appendicostomy. — By the operation Appendicostomy is understood the creation of an artificial fistulous communication between the lumen of the cæcum and the surface of the anterior abdominal wall in the right inguinal region, the mucous-membrane-lined canal of the vermiform process (appendix) being utilised in the formation of the fistulous track.

Indications.—The chief indication for this operation is the existence of a pathological condition of the large intestine, in which it is considered desirable periodically to wash out the large intestine for its entire length or to apply to it some form of medicament. The greatest benefits have followed in cases of mucous colitis, and of dysenteric ulceration of the colon. Patients suffering from extensive ulceration of the large intestine, especially when tubercular in nature, have not been benefited materially in most cases. The operation has also been performed for severe and intractable constipation, but in these patients the good results obtained have generally been only of a temporary character.

Position.—The patient is placed in the dorsal position ; the surgeon stands on the right, opposite the pelvis, and the assistant on the left.

Operation.—An incision 2 inches long is made as for removal of the vermiform process (appendix) by the " gridiron " method. The peritoneal cavity is opened, and the process sought for, freed from any adhesions which may be present, and delivered through the parietal opening. Its base is then fixed to the margins of the deep part of the incision by the insertion of several points of catgut suture, especial care being taken not to include the artery of the vermiform process (appendicular artery), otherwise gangrene of the entire process may follow. In a similar manner the apical portion is attached to the margins of the skin incision, about ½ inch being allowed to protrude. The remaining portions of the incision in the abdominal wall are next closed by careful suturing and dressings applied. After the expiration of four or five days, the dressings are removed and the protruding apex cut off. A fistulous opening is thus established, through which a conical rubber catheter can be passed and saline solution or other medicament introduced into the interior of the cæcum. When it is no longer desired to use this opening, if left alone it usually closes in a short time.

Excision of the cæcum and ascending colon.—In excision of the cæcum it is generally advisable to remove the ascending colon and first half of the transverse colon. In this way the part of the bowel in which retro-peristaltic movements take place is eliminated and regurgitation into the ileum, which has been made possible by loss of the ileo-cæcal valve, is not so marked.

Indications.—(*a*) Certain cases of tuberculosis and actinomycosis of the cæcum, when the disease is localised to this portion of the intestine.

(*b*) Primary malignant growths, which have not extensively involved adjacent structures.

Removal of the cæcum may also be necessary in cases of inveterate fæcal fistula communicating with the interior of this part of the gut; and in occasional cases of cæcal hernia, when inseparable adhesions with the hernial sac have formed.

Special instruments.—Short intestinal clamp, thermo-cautery.

Position.—The patient is placed in the dorsal position, with a sandbag under the right side tilting him slightly to the left. The operator stands on the right side and the first assistant on the left.

Operation.—The operation may be divided into five stages:—

(*a*) *Parietal incision.*—An incision 6 to 8 inches long is made in the right linea semilunaris, the centre point being opposite the umbilicus. The incision is deepened until the peritoneum is opened, care being taken to avoid section of nerves, which should be retracted up or down.

(*b*) *Mobilisation and delivery of the cæcum and ascending colon.* — The margins of the wound are retracted and the coils of small intestine packed over to the left side. In the lower part of the wound the ileo-cæcal artery is identified and ligatured and divided close to its origin, and next the right colic artery is ligatured and divided. The peritoneal attachments of the colon to the duodenum are carefully divided, and the peritoneum incised along its reflection from the right side of the cæcum and ascending colon to the abdominal wall. The gut is now carefully stripped from the posterior abdominal wall and turned to the left side, care being taken to avoid injury to the ureter. Bleeding is controlled first by sponge pressure and then by ligature of vessels, and the terminal portion of the ileum, the cæcum, the ascending colon, and part of the transverse colon delivered through the wound.

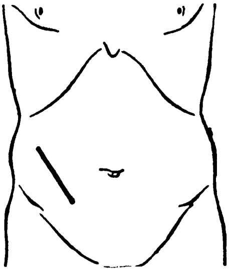

FIG. 126. — Excision of cæcum. Position of parietal incision.

(*c*) *Removal of cæcum, ascending colon, and proximal half of transverse colon.*—The terminal portion of the ileum is packed off by swabs, its contents emptied into the cæcum, and short intestinal clamps are applied transversely about ½ inch apart, the distal clamp being 3 to 4 inches from the ileo-cæcal valve. The gut is now divided between the clamps with the thermo-cautery. The mesentery of the distal part of the ileum is transfixed and ligatured in two or three places and divided. A place is selected in the transverse colon about its middle, which is clamped

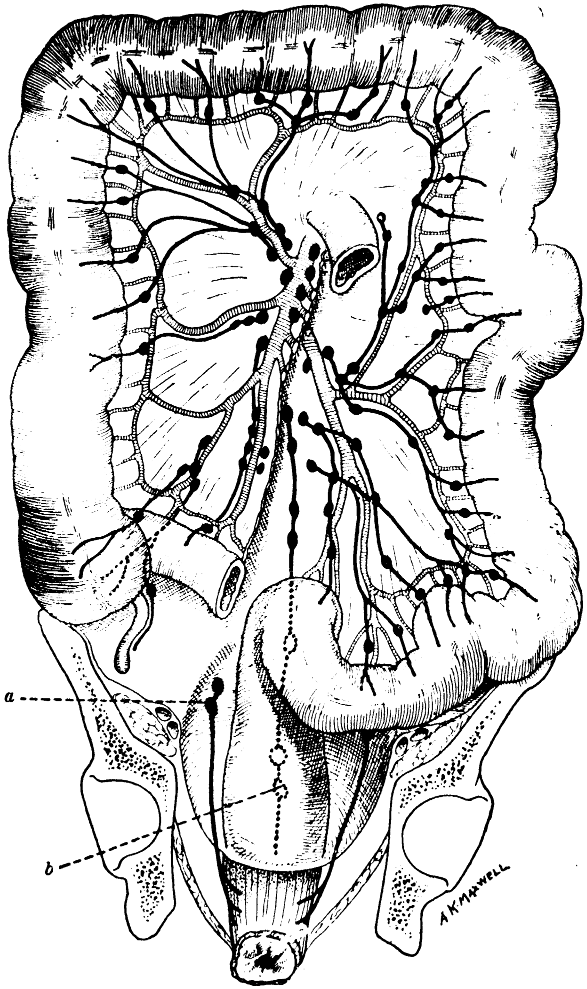

FIG. 127.—Course of lymph vessels and position of lymph glands receiving lymph vessels from large intestine and rectum (except anal region).

a. Lateral pelvic lymph glands.
b. Lymph glands in hollow of sacrum and meso-rectum.

and divided in a similar manner. The mesentery of the proximal portion is transfixed in several places, ligatured, and divided. The omentum is separated from the freed portion of gut and bleeding points tied. The remaining attachments of the ascending colon are ligatured and divided and the freed bowel removed.

(*d*) *Closure of divided ends of ileum and transverse colon and lateral anastomosis.*—The divided end of the ileum is closed by a continuous suture of silk, and invaginated into the lumen of the bowel by a purse-string suture of catgut after removal of the clamp. The divided end of the transverse colon is closed in the same way. Next a lateral anastomosis is made between the ileum about 2 inches from its extremity, and the distal portion of the transverse colon. If possible, the peritoneum of the posterior abdominal wall should be freed and united over the bare area.

(*e*) The anterior abdominal wall is closed without drain, unless there is much oozing.

Intussusception.—*Indications.*—An operation for the relief of this condition ought to be immediately carried out in all cases in which the diagnosis is apparent and efforts at digital reduction of the tumour have failed. The position of the intussuscepted portion can generally be made out by palpating the abdomen and feeling an elongated tumour in the line of the colon, by rectal examination, or by a bimanual examination with the finger in the rectum.

Operation.—An incision 2½ inches long is made one-third above the umbilicus and two-thirds below it, and a little to the right of the middle line. The abdominal cavity being opened, the forefinger is first passed into the right iliac fossa and then along the course of the colon until the tumour caused by the intussusception is located. When the tumour has been found it is brought into the abdominal wound. Combined gentle traction, and squeezing and manipulation of the distal portion of the swelling are then carried out, and the tumour reduced. Much assistance may often be obtained in reduction by taking the tumour between the two hands and exerting firm pressure upon it for a few minutes, so as to reduce the blood and serum in it. Attempts at reduction—slight traction on the entering piece, and manipulation and squeezing of the distal end—will then, in nearly all cases, be successful. When the gut is gangrenous, resection of the dead portion and end-to-end or lateral anastomosis should be carried out, as described on page 120 *et seq.*

When reduction has been successfully accomplished, the gut is returned into the abdomen and the parietal wound closed by tiers or sutures.

Resection of the large intestine.—The methods which are adopted for the removal of portions of the large intestine are similar to those which have been already described in connection with the surgery of the small intestine.

The chief indications for removal of portions of the large intestine are :—

(*a*) Localised malignant growths.
(*b*) Gangrene in connection with strangulated hernia.
(*c*) Severe lacerations of the intestine as a result of a severe injury ; and
(*d*) Some forms of severe localised ulceration.

Colostomy—Inguinal colostomy.—Inguinal colostomy has for its object the creation of a fistulous communication between the lumen of the colon and the surface of the abdomen in the inguinal region. The operation is usually performed on the left side, the termination of the descending colon becoming the seat of the fistula ; but occasionally the artificial anus is made on the right side, and the cæcum or ascending colon is opened.

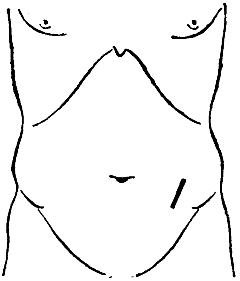

FIG. 128.—Left inguinal colostomy. Position of parietal incision.

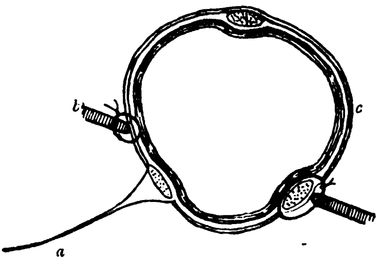

FIG. 129.—Inguinal colostomy. Diagrammatic section through the descending colon, showing insertion of sutures.
a. Mesentery. *b.* Abdominal wall. *c.* Colon.

Indications.—Inguinal colostomy may be performed, either as a measure for the cure of a disease, or as a procedure for the prolongation of life, the prevention of impending death, or the amelioration of a patient's condition. The operation is performed in recto-vesical fistula which cannot be closed by a local operation, in certain varieties of non-malignant ulcerations of the rectum, and in congenital malformations in which the anus and rectum are absent. It is also often performed as a preliminary procedure to excision of the rectum by the abdomino-perineal method. As a proceeding for the prolongation of life, it is most commonly performed on patients suffering from cancer of the rectum when the growth cannot be removed satisfactorily.

Position.—The patient is placed in the dorsal position near the left side of the operating table. The surgeon stands on the left side of the patient, and the chief assistant opposite to him.

Special instrument.—Intestinal clamp.

Operation.—Inguinal colostomy may be divided into three stages, namely :—

(*a*) *Parietal incision.*—An incision from 2 to 3 inches in length (Fig. 128), according to the obesity of the patient and the thickness of the abdominal walls, is made in the following manner : An imaginary line is taken from the left anterior superior iliac spine to the umbilicus, and a point is selected along this line one-third of the distance from the iliac spine. The incision is made to pass through this point at right angles to the imaginary line, one half being above and the other half below the imaginary line (Fig. 128). All the strata of the abdominal wall are divided—first the external oblique, next the internal oblique and tranversus abdominis (transversalis), each muscular layer being divided parallel with the direction of its fibres until the peritoneal cavity is opened.

Another incision may be made through the lower half of the left rectus. It is vertical, 2 to 3 inches long, and commences a couple of inches below the level of the umbilicus. The outer layer of the rectus sheath is divided and the muscle fibres separated, and the posterior layer of the sheath and the parietal peritoneum incised. The advantages of this incision over the former are that (1) a better sphincter action can be obtained by the rectus than by the other abdominal muscles, and (2) a much more satisfactory colostomy belt can be fitted. Its disadvantage is that it is more difficult to keep clean in people who have much hair on the lower abdomen.

(*b*) *Finding of the bowel and fixation to the abdominal wall.*—The colon may at once protrude in the wound, but if not, the fingers are passed into the peritoneal cavity and the large intestine sought for. It will usually be found a little below and external to the incision. In abnormal conditions it may be found over the brim of the pelvis and towards the right side. The large intestine can be recognised by its sacculations, the thinness of its walls, the presence of appendices epiploicæ upon its surface, and the arrangement of its longitudinal muscular coat in the form of three distinct bands, one of which is directly opposite the mesenteric attachment. In order to prevent prolapse, the iliac colon and the descending colon are drawn down from above until the upper segment is quite taut, the coil being passed in again below. A loop of intestine is then selected as high up as possible, and into the convexity two guiding sutures are passed, 2 inches apart, and through the serous and muscular coats. These sutures are left as loops, one knot being placed on the upper and two on the lower, in order to enable the surgeon to recognise the exact position of the intestine when it is opened in the third stage of the operation. A double suture of thick silkworm gut threaded on a large curved needle is passed through the skin, muscle, and peritoneum from one side of the wound, through the mesentery of the loop of gut, and then the peritoneum, muscle, and skin of the other side of the wound. The ends of the suture are temporarily anchored by pressure forceps. A similar suture is passed ½ inch from the first, and the adjacent ends of the sutures tied together. In this way a bridge is formed upon which the loop can rest. The peritoneum at the upper and lower corners of the wound is fixed to the anterior linea longitudinalis of the bowel by a catgut suture. This should suffice to shut off the peritoneal cavity completely. It may, however, be necessary to attach the peritoneum to the bowel by

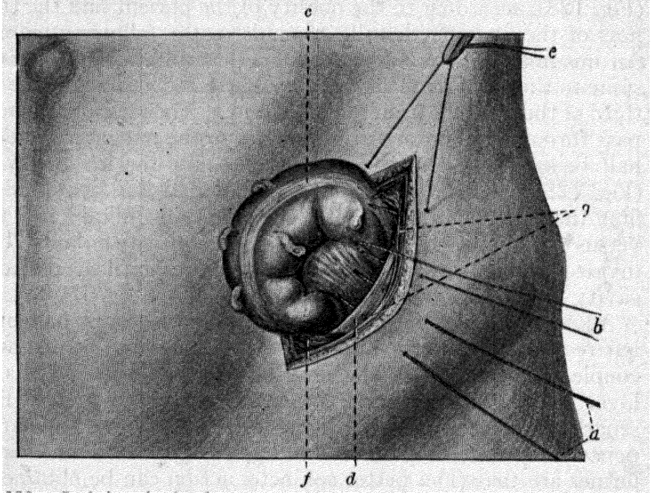

FIG. 130.—Left inguinal colostomy. Method of fixation to abdominal wall.

a. Suture passing from side to side through meso-colon.
b. Lateral suture.
c. End suture.
d. Parietal peritoneum.
e. Colon with longitudinal band, etc.
f. Internal oblique and transversus abdominis (transversalis).
g. External oblique.

one or two more sutures. If the parietal wound has been made larger than the protruded loop of intestine, the portions to which the intestine is not attached are closed in the usual manner.

(*c*) *Opening of the gut and making an artificial anus.*—The intestine may be opened at the time of the operation: when opened at a subsequent date the administration of an anæsthetic is not necessary. If the symptoms are not urgent it is advisable to leave it for three to five days, a dressing, having a layer of protective or rubber sheeting next to the bowel, being applied in the meantime. In opening the bowel the two guiding sutures are taken, one is given to an assistant to hold, and an opening is made into the interior of the gut by cutting between these sutures with a scalpel. The superfluous portions of the gut around the artificial anus are trimmed away with scissors, and all bleeding points ligatured. The hæmorrhage may be considerable.

Prolapse of the mucous membrane of the portion of the intestine immediately above the external aperture very rarely follows this operation. In order to control the escape of fæces it is advisable to fit up the patient with a truss similar to the one figured in Fig. 131.

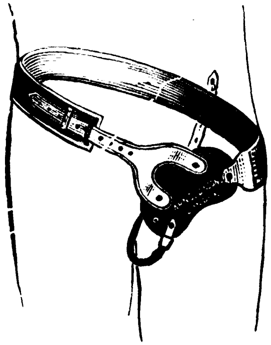

FIG. 131.—Inguinal colostomy. Truss for use after this operation.

Inguinal colostomy without sutures (Maydl and Reclus' operation).—The early stages of this operation are exactly similar to those of the operation above described. When the loop of descending colon has been brought into the parietal wound, and made taut above, a small aperture is made in the mesentery immediately behind the bowel and in the middle part of the loop, and through this a glass rod, about 4 or 5 inches in length, is passed, and fixed to the abdominal wall by two pieces of strapping. The rod is so placed that the loop of intestine lies in front of it, and it is fixed in a position at right angles to the long axis of the external wound. Dressings are applied in the usual manner, and at the end of a few days, according to the urgency of the case, the bowel is opened in a manner similar to that described above. The glass rod should be left in position for a week, and then removed.

The advantages which are claimed for this operation are the short time necessary for its performance, the well-marked "spur" obtained, and the excellent results which have followed its adoption. In my opinion, however, the "suture" method is the best.

Inguinal colostomy with immediate opening of the gut.—In some cases it is desirable to afford instant relief to the intestinal obstruction, whilst the patient's condition will only warrant the smallest operation possible. For these it is convenient to adopt the appliance known as "Paul's tube," which consists of a glass tube about ¾ inch in diameter and 5 inches long, bent at right angles near the centre and having a double flange at one end.

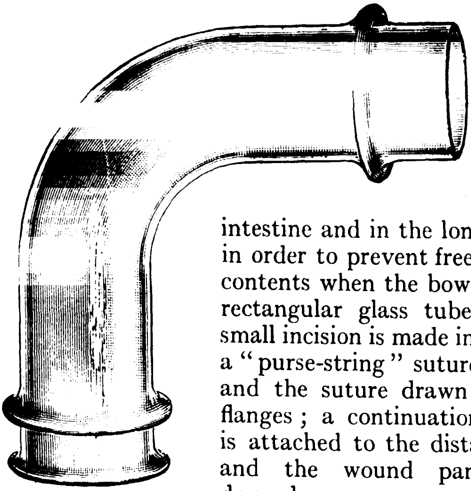

Fig. 132.—Glass tube for use when the colon is opened at once.—Paul.

The gut having been found and fixed to the abdominal wall, as described above, an intestinal clamp (Fig. 103), is applied to the protruding loop of intestine and in the long axis of the bowel in order to prevent free escape of intestinal contents when the bowel is incised and the rectangular glass tube inserted. Next a small incision is made in it, surrounded with a "purse-string" suture, the tube inserted, and the suture drawn tight between the flanges; a continuation of rubber tubing is attached to the distal end of the tube, and the wound partially closed and dressed.

The end of the rubber tubing is maintained in connection with a suitable vessel under the side of the bed.

Operations upon the Rectum and Anus

Hæmorrhoids.—Hæmorrhoids or piles frequently require surgical treatment. The varieties of operation which may be adopted are the following, namely—(*a*) Treatment by ligature, (*b*) treatment by excision, (*c*) treatment by crushing. The method of treatment by ligature appears to be the most satisfactory, and moreover it is the easiest to carry out. The three operations will be described in order.

(*a*) *By ligature.*

Special instruments.—Clover's crutch, scissors, volsellum or pile forceps, and large size drainage tube.

Position.—The patient is placed in the lithotomy position, Clover's crutch being used, and the buttocks made to project slightly over the end of the operation table. The surgeon sits opposite the perineum, and the assistant stands on his right hand For some of the slighter operations the right lateral and semi-prone position may be found convenient, the surgeon standing behind the patient.

Operation.—As a preliminary to most operations upon the lower part of the rectum, which are carried out from its interior, it is necessary to dilate the anus and cause temporary paralysis of the sphincters. This is done by introducing the index fingers or thumbs of both hands through the anal aperture, and exerting continuous and firm traction, until the sphincter is felt to relax or give way. When this occurs the pressure from within is diminished so as to avoid laceration and tearing of the muscle. In order thoroughly to dilate the anus in this manner, it is usually necessary to exert traction for one to three minutes. When the anus has been sufficiently dilated the hæmorrhoids prolapse and become evident.

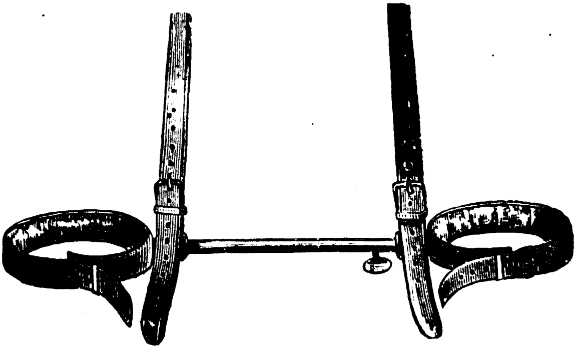

FIG. 133.—Clover's crutch, for maintaining a patient in lithotomy position.

Application of the ligature.—The most prominent pile at the posterior margin of the anus is seized with the volsellum forceps and drawn inwards towards the middle point of the enlarged anal aperture. This renders apparent the junction of the skin and the mucous membrane. The scissors are taken, and a cut is made at the base of the pile and along the mucous-cutaneous junction ; and the hæmorrhoidal mucous membrane, with the attached pile, dissected upwards for a short distance until a distinct pedicle to the pile has been made. It is only necessary as a rule to make a few snips with the scissors in order to effect this. A strong silk ligature is then placed in the groove between the pile and the skin, the forceps and attached pile are pulled slightly outwards and downwards, and the ligature is tied in such a manner that all the blood vessels going to the pile are obstructed, and the knot is so placed that it lies upon the mucous membrane of the rectum. Transfixion of the base of the pile and ligature by a "Staffordshire" knot is another method by which this object may be effected. Any other piles which may be present are treated in a similar manner, but it is not necessary even in severe cases to apply more than four ligatures. When all the ligatures have been tied, the distal portions of the piles are cut away, care being taken to leave a distinct button of tissue to prevent the ligature slipping. The ligatures are cut short, the area of operation washed with saline solution, and dressing applied and held in position by a perineal bandage.

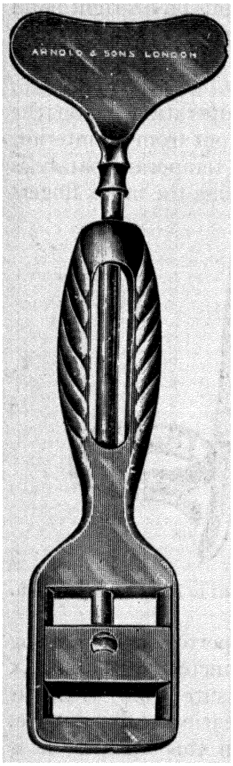

FIG. 134.—"Pile-crushing" clamp.

Care must be taken in this operation not to include any of the skin of the anal margin, otherwise much pain may be induced, or it is possible that a stricture of the anus may afterwards develop.

(*b*) *By excision* (*Whitehead's operation*).

Instruments.—These are similar to the instruments required for ligature, with the addition of dissecting forceps and suture needle with needle-holder.

Position, as for ligature.

Operation.—The mucous membrane of the rectum is divided with scissors, at its junction with the skin, for the entire circumference of the anus, any irregularities of the skin being followed. By dissection, the hæmorrhoidal portion of the mucous membrane is separated from the submucous tissue which lies between it and the subjacent muscle, and then the ring of piles and mucous membrane is pulled down below the level of the anus. The mucous membrane is now divided just above the "hæmorrhoidal area," and the diseased portion removed. The cut edge of the mucous membrane is united to the free margin of the skin by the insertion of a number of sutures. This is best done in stages; as a portion of the mucous membrane is divided, it is stitched to the free margin of the skin.

All the ligatures are cut short and a dressing applied, as in the previous operation.

(*c*) *By crushing.*

Instruments.—The instruments for this operation are the same as for ligature, with the addition of the special form of "pile-crushing" clamp preferred by the operator.

Position.—The position of the patient and operator are the same as for ligature.

Operation.—The anal sphincter is dilated in the usual manner, so as to allow of free access to the piles. The most prominent pile is selected, and the aperture in the clamp placed over it (Fig. 134). A pair of volsellum forceps is passed through this aperture, and the pile seized and drawn through the opening. Whilst it is held in this position, the clamp is quickly screwed up tightly and the contained pile crushed. The clamp is left on for two or three minutes, and the projecting portion of the pile removed with scissors or a cautery. The clamp is then unscrewed and removed, and if any bleeding points appear they are picked up with pressure forceps and tied. Any other piles which may be present are treated in a similar manner. When this has been done the region of the anus is freed from blood-clot, and a dressing applied.

This operation does not appear to present any advantages over the "ligature"; it takes much longer to perform, and is, moreover, more likely to be followed by hæmorrhage.

Prolapse of the rectum.—Prolapse of the rectum, in those cases in which an operation is required, may be treated either by cauterisation of the prolapsed portions of mucous membrane, or by ligature and excision of several strips of mucous membrane, each strip including an internal hæmorrhoid when this condition is present.

(*a*) *Operation by cautery*:—

Special instruments.—Paquelin's thermo-cautery and a large Sims' duckbill speculum.

Operation.—The patient having been placed in the lithotomy position, and the prolapsed mucous membrane reduced, a large *duckbill* speculum is passed into the rectum through the anal orifice, and the exposed mucous membrane sponged dry. A Paquelin's thermo-cautery is taken, the point at a dull red heat, and a line is traced on the mucous membrane of the bowel in the direction of its long axis opposite to the speculum, commencing about 3 inches above the anal margin and terminating below at the muco-cutaneous junction. Four vertical lines of cauterisation are made, one anteriorly, one posteriorly, and one on each lateral aspect, the speculum being twisted round as may be requisite. The cauterisation must not extend beyond the thickness of the mucous membrane.

This operation is most applicable when the prolapse of the mucous membrane is not associated with piles.

In children, application of nitric acid has been recommended instead of cauterisation with the actual cautery, but in my opinion better results are obtained by the method above described.

(*b*) *Operation by ligature and excision.*—The patient having been placed in the lithotomy position, the prolapsed mucous membrane is reduced, and the anal aperture dilated with the fingers if necessary. The exposed mucous membrane is sponged clean, and the exact position of any internal piles which may be present determined. The most prominent pile is next picked up and raised with pressure forceps, and a V-shaped incision is made to enclose it, and extend upwards into the mucous membrane of the prolapse. The apex of the V is below and the base above. The V-shaped portion of mucous membrane is then dissected upwards from the underlying muscular wall, and a strong silk ligature applied to it at the base. The distal portion may then be cut away. Other piles are then taken and treated in a similar manner. Usually about three ligatures are sufficient. Strips of mucous membrane must be left between the ligatures, otherwise stenosis of the anal orifice is almost certain to result.

Operation for "fistula in ano" (rectal fistula).—*Special instruments.*—Clover's crutch, probe-pointed director, and sharp-pointed curved bistoury.

Position.—The patient is placed in the lithotomy position, Clover's crutch having been applied, with the buttocks projecting just beyond the end of the operation table. The operator sits opposite the perineum, and the assistant stands on his right hand.

Operation.—The anal sphincter is dilated (cf. p. 151), and if the fistula has an external opening, a probe-pointed director is pushed through it, made to pass along the track of the fistula and emerge in the cavity of the rectum through the internal aperture, if one is present; or if not, the point is forced through the thinnest portion of the mucous membrane which intervenes between the fistulous track and the lumen of the bowel. When the internal opening is only a short distance above the anal margin, the point of the director is brought out through the anus. If this can be done a sharp-pointed bistoury is passed along the groove in the director, and all the tissues between the fistulous track and the surface divided. When the internal aperture is situated so high within the bowel that this cannot be done, the forefinger of the left hand is passed into the rectum to the point of the director as it protrudes through the internal opening, and with a pair of scissors the intervening tissues between the track of the fistula and the lumen of the intestine are divided. Some surgeons in these cases pass a rounded piece of soft wood into the rectum as far as the internal opening of the fistula, and then a sharp-pointed bistoury is pushed along the fistulous track, until the point pierces the piece of wood within the rectum. The bistoury and the piece of wood are next withdrawn together, and the

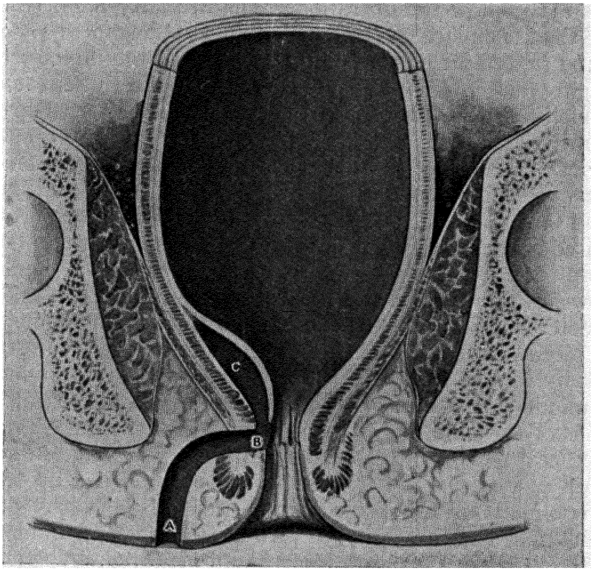

Fig. 135.—Complete rectal fistula.—Ball.

A. External opening and track.
B. Opening into rectum.
C. Track extending above opening into rectum.

tissues divided. When the chief fistulous track has been opened by one of these methods, an examination of its upper extremity should be made, to ascertain whether there is a submucous track extending farther upwards, and if so, as is usually the case, it is opened up with scissors on a director, unless it extends so far that there is danger of hæmorrhage occurring where it cannot readily be controlled. Next, the lateral prolongations of the fistula are opened up. Care must be taken not to divide the external sphincter in more than one place, otherwise incontinence of fæces may follow the operation. The necessity for division in more than one place can be avoided, in most instances, by opening the superficial portion of the sinus until the director has a straight track into the lumen of the bowel. In those rare cases in which there are two internal openings it is better to open up the more extensive and larger fistula, and to scrape out the interior of the other one with a fine Volkmann's spoon, since in most cases this second track will close, whilst the one which is laid open is granulating up. When the fistulous aperture is situated in the central part of the female perineum, the sphincter should not be divided here, since incontinence generally follows, owing to the interlacement of the fibres of the external sphincter ani and the sphincter vaginæ at this point. The best method of treatment in these cases is to treat the fistulous track by scraping, and then to divide the external sphincter in the middle line behind. The fistula will generally heal after this has been done, since the contractions of the muscle do not force fæcal matter into the sinus, and the walls are allowed to remain at rest. When the fistula has been opened up by one of these methods, any projecting portions of unhealthy skin or granulation tissue are removed with the scissors, and all bleeding points seized with pressure forceps and ligatured. The area of the operation is washed so as to free it from blood-clot, and a strip of moistened gauze is placed in the bottom of the track, and a dressing is applied.

After-treatment.—The ultimate success of this operation depends upon the careful after-treatment. The wound should be kept as clean and aseptic as possible by daily irrigation, and after this has been done a strip of lint or gauze is placed (as above) between the cut surfaces, so as to ensure healing up from the bottom and prevention of bridging over, which may be the cause of the development of secondary fistulæ. If any union of the granulations of the two sides is noticed, it ought to be broken down with a probe.

Excision of the rectum.—Excision of the rectum may be either partial or complete; in the majority of instances the former. It is usually performed on account of a malignant growth, and the variety of operation which ought to be recommended depends upon the position and extent of the primary growth, its connections, or extension to adjacent structures, and the presence or absence of secondary deposits in the lymph glands which receive the lymph vessels from the affected area, or in the lymph glands and the viscera elsewhere.

The varieties of operation for removal of a portion or the whole of the rectum may be arranged in four groups :—

1. *Removal from the perineum.*—(*a*) Partial ; (*b*) *Complete.*
2. *Removal by abdominal method.*
3. *Removal by the abdomino-perineal method.*—(*a*) With the formation of a perineal anus ; (*b*) With the formation of a left inguinal anus.
4. *Removal by the vaginal method.*

Kraske's operation and its various modifications have fallen into disuse owing to the improved results which have been obtained by the abdomino-perineal method.

Often it will be necessary, when the upper portion of the rectum is the seat of disease, and the lower part of the pelvic colon is invaded, first to make an abdominal incision, in order to determine the possibility of complete removal, and this having been decided upon as desirable, to free the portion of bowel which is involved, and to complete the procedure from the perineum.

Preliminary inguinal colostomy.—The advisability or non-advisability of performing a preliminary inguinal colostomy depends in great measure upon the occurrence of symptoms of obstruction. If there is no evidence of complete or considerable blocking of the lumen of the bowel, and it is possible satisfactorily to evacuate the alimentary canal by the administration of aperients and enemata, then it is rarely necessary to perform a preliminary colostomy; but if the growth has considerably encroached upon the bowel and caused obstruction, then a preliminary inguinal colostomy should be performed, and a few days later, when the intestinal canal has been satisfactorily emptied, the removal of the desired portion of the rectum by one of the methods to be described is undertaken. Resection of a portion of the large intestine and end-to-end anastomosis, when obstruction exists at the time of operation, is generally followed by a fatal result, owing to the difficulty experienced in getting the sutured tissues to join together consequent upon paralysis of the gut.

Choice of operation.—The choice of the form of operation which ought to be adopted in the operative treatment of carcinoma of the rectum or the lower portion of the pelvic colon is governed, in the main, by the position and extent of the primary growth, by the presence or absence of secondary deposits in lymph glands or internal viscera, and by the physical condition of the patient.

As a general rule it may be stated that if a carcinoma of the rectum is limited to the lower three inches of the bowel, and does not extend through the submucous coat so as to infiltrate the muscular wall, and at the same time is not associated with secondary visceral growths, it ought to be removed by the perineal route. When the carcinoma involves the muscular wall of the rectum or if the upper part of the rectum and the lower portion of the pelvic colon is the seat of disease, the combined abdominal and perineal methods or abdomino-perineal method is the best. In those cases in which the vagina or the cervix of the uterus are involved in the disease the vaginal or complete perineal operations offer the best chances of a cure.

Excision of the rectum (from perineum)—Partial.—*Indications.*—Partial excision of a portion of the rectum by the perineal method is indicated in those cases of carcinoma in which the neoplasm involves the lower three inches of the bowel and does not extend to the adjacent structures. The finger ought to be passed beyond the region of the growth, and be able to feel healthy mucous membrane above.

When there is extensive infiltration of the surrounding tissues, or there are signs of secondary growths in other parts, any operation is contra-indicated.

The anatomical relations of the rectum and its relations to the surrounding structures are shown in Fig. 136, which is a representation of a vertical section through the male pelvis.

Special instruments.—Strong, curved, sharp-pointed bistoury, straight probe-pointed bistoury, blunt-pointed and curved scissors, volsellum forceps and catheters.

Position.—The patient is placed in the lithotomy position, with the buttocks projecting slightly beyond the end of the operation table, and raised somewhat by a pad. The surgeon stands or sits opposite the perineum, and the assistant stands on his right hand.

Operation.—The operation may be divided into three stages. It may be advisable to perform left inguinal colostomy as a preliminary measure.

(*a*) *External incisions.*—The forefinger of the left hand is passed into the rectum, until the tip of the coccyx can be felt (beyond the growth, if possible). A sharp-pointed curved bistoury is taken, passed into the rectum along the curve of the finger, and made to transfix the posterior wall of the rectum and all the tissues which lie between it and the tip of the coccyx, until the point emerges through the skin at the apex of the coccyx. A cut is made towards the anus with the bistoury, so as to divide all the tissues between the tip of the coccyx and the median line of the posterior margin of the anus. It is im-

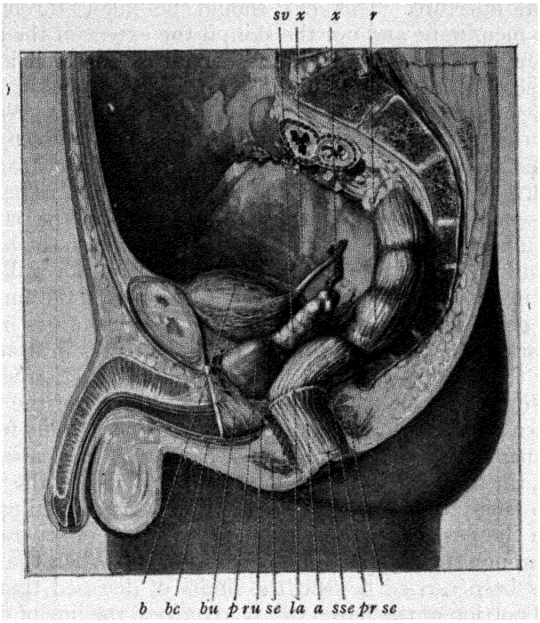

FIG. 136.—The relations of the rectum to the male genito-urinary organs. The pelvic viscera have been dissected out of the left half of the body and placed *in situ* on the section of the right side.—CUNNINGHAM.

b.	Bladder.
bc.	Bulbo-cavernosus muscle (ejaculator urinæ).
bu.	Bulb of the urethra, with covering muscle removed.
p.	Prostate gland.
ru.	Recto-urethral muscle.
se.	External sphincter muscle.
la.	Levator ani muscle cut across.
a.	Anal canal covered by some fibres of levator ani muscle.
sse.	Superficial fibres of external sphincter muscle.
pr.	Pubo-rectal muscle (Levator ani).
r.	Rectum.
x.	Marks the point upon each side where the ductus (vas) deferens crosses the ureter.
sv.	Seminal vesicle.

portant to keep in the middle line, so as to avoid unnecessary hæmorrhage. A semicircular cut is next made around each lateral margin of the anus, commencing at one side of the median posterior incision, and terminating at a point in front of the anal aperture. This cut should be made through the mucous membrane and not the skin, if the extent of the growth will allow of this being done, and should extend well into the ischio-rectal fossa on each side.

(*b*) *Separation of the lower portion of the rectum.*—With the fingers the posterior and lateral portions of the rectum are separated from the surrounding tissues, until the levator ani is reached. This structure is divided with scissors. The bowel is next separated from its connections in front. If the patient is a male, a bougie No. 12 E. or catheter is passed into the bladder, and held in position by the assistant. The anterior wall of the rectum is seized either with volsellum forceps or the fingers of the left hand, and drawn backwards. The connections between the anterior wall of the rectum and the structures in front of it, notably the prostate, are divided by careful dissection with the scissors or scalpel, or both, until the upper limits of the disease have been passed. The catheter or bougie can be readily felt, and any damage to the urethra easily avoided. If the patient is a woman, the finger of the assistant should be placed in the vagina, so as to facilitate the separation and avoid making an aperture through the posterior vaginal wall. The plane of separation is made through the vaginal submucous tissue. When the dissection has been carried beyond the limits of diseased tissue, the affected portion of the bowel can be removed, the line of division being through healthy tissue above the growth.

(*c*) *Removal of the bowel along with diseased tissues.*—The lower portion of the rectum is seized with volsellum forceps, and drawn downwards. With a strong pair of scissors the rectal wall is cut through transversely at the upper limit of the wound. It must be remembered that the peritoneum extends to within 2½ or 3 inches of the anus on the anterior aspect of the bowel; posteriorly it does not reach lower than about 5 inches from this point. As the division is effected, free hæmorrhage occurs, which is controlled by at once seizing, with pressure forceps, each blood vessel as it commences to bleed. The diseased portion of the rectum, together with the growth, having been removed, all bleeding points are ligatured with fine silk, and the ends of the ligatures cut short. When all hæmorrhage has been arrested, the field of operation is examined, so as to make sure that no diseased tissue has been left behind. It is of no advantage to bring down the divided edge of the mucous membrane and stitch it to the margin of the lower portion of the wound, since it has been found that the sutures always cut out, and serve no practical purpose. A rubber tube is now passed into the cavity of the rectum, and allowed to project through the external aperture. The space around is packed with gauze and wool, and a perineal bandage applied. The tube allows the passage of blood and gas from the rectum, and so removes a source of discomfort to the patient.

After-treatment.—This has for its object the prevention of septic processes and the development of cicatricial contraction. The first complication is avoided by attention to cleanliness, and the avoidance of the accumulation of any discharge which may undergo decomposition. The occurrence of cicatricial contraction is prevented by the daily passage of a rectal bougie during the process of healing of the wound. The passage of this instrument should be commenced immediately signs of contraction appear. Contraction usually commences within two to four weeks from the time of the operation. The bougie should be left in for one-half to one hour each day, if it does not cause much discomfort. When the wound has healed, a process which takes about two months, the bougie is passed every other day for about a year. The instrument is simply passed in and out, and not left for any length of time within the rectum.

Excision of rectum (from perineum)—Complete.—*Indications.*—This form of removal of the rectum is indicated when the carcinomatous growth which necessitates the operation involves the upper portion of this part of the alimentary canal, or extends to the adjacent piece of the pelvic colon, and is in close connection with the prostate or the cervix uteri.

Position.—The patient may be placed in the semi-prone position and lying upon the right side, or in the lithotomy position with the pelvis slightly elevated. In the former case the surgeon stands opposite the gluteal region, with an assistant on each side; and in the latter, he sits opposite the perineum, and an assistant stands on each side. In the majority of instances the former position will be found the more convenient, especially if the operation table can be raised to a convenient level.

Operation.—(*a*) *External incision and ligature of rectal mucous membrane.*—The anal aperture is dilated with the fingers, the cavity of the lower portion of the rectum washed out, dried by sponging and packed with a long strip of gauze. The muco-cutaneous margin is next incised in an elliptical manner, and the mucous membrane of the rectum dissected upwards for about 1 inch, and securely tied by encircling the separated portion of mucous membrane with a strong silk ligature. The end of the separated mucous membrane is then surrounded with a pad of gauze.

(*b*) *Removal of coccyx and exposure of lower part of rectum.* —The extremities of the incision around the anus are next extended forwards into the perineum, and backwards a little beyond the apex of the coccyx, the incision being made to extend through or to separate the fibres of the external sphincter ani. The margins of the wound are next held aside with wide retractors, the coccyx removed after cutting through its ligamentous connections, and the rectum exposed on its posterior and lateral aspects by blunt dissection. The levator ani on each side is now cut through close to the rectum, the incision commencing posteriorly and extending forwards on each side, the anterior fibres being cut last, care being taken to avoid damaging the adjacent viscera. The rectum having been drawn downwards by exerting traction from below, it is separated with the point of the index-finger from the anterior aspect of the sacrum behind, and the loose fascial and connective tissues on its lateral aspects. When the patient is a man, a No. 12 metal sound is passed into the bladder and held well forward by an assistant, whilst the surgeon separates the anterior aspect of the rectum from the posterior aspect of the urethra and prostate by carefully cutting the fibrous connections with blunt-pointed scissors. On account of the intimate and close relations of these structures the separation must be carefully carried out, otherwise the lumen of the urethra, bladder, ureters, or rectum may be inadvertently opened. If the patient is a woman, an assistant should pass an index-finger into the vagina in order to facilitate the separation, which is carried out by carefully cutting with scissors.

(*c*) *Opening of peritoneal cavity and separation of upper portion of rectum, and if necessary lower portion of pelvic colon.* —The dissection is continued upwards anteriorly until the lower part of the peritoneal pouch is exposed. This is opened at the lowest part, and the incision prolonged through the peritoneum on each side of the rectum until the meso-rectum and the lower portion of the pelvic meso-colon and the anterior aspect of the sacrum are reached, the former being cut through close to the latter. By this means the blood supply of the upper portion of the rectum is not seriously interfered with, and the lymph glands in the hollow of the sacrum and between the layers of the meso-rectum—which may be the seat of secondary growth—are laid bare and can be readily taken away. It is advisable to divide the peritoneum on the side of the meso-rectum and pelvic meso-colon to a higher level on the left, in

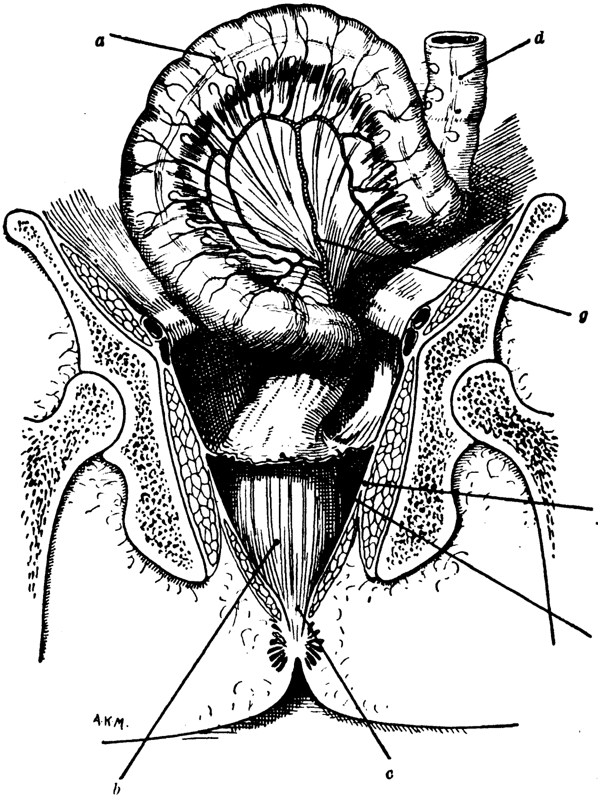

FIG. 137.—Coronal vertical section through pelvis in front of anus, showing arrangement of peritoneum, and distribution of superior hæmorrhoidal artery.

a. Pelvic colon.	*e*. Reflection of peritoneum from front and sides of rectum.
b. Rectum.	*f*. Obturator internus.
c. External sphincter ani.	*g*. Artery to pelvic colon.
d. Descending colon.	

order to facilitate the drawing down of the upper portion of the rectum and the lower part of the pelvic colon towards the anal outlet of the pelvis. The rectum having been separated from its surroundings, and the pelvic meso-colon partially cut through, the carcinomatous growth is drawn downwards beyond the anal margin, so as to allow of the section of the bowel being made at least 1½ inches above the upper margin of the diseased area; the upper portion of the field of operation is packed with gauze pads, and the two branches of the superior hæmorrhoidal artery

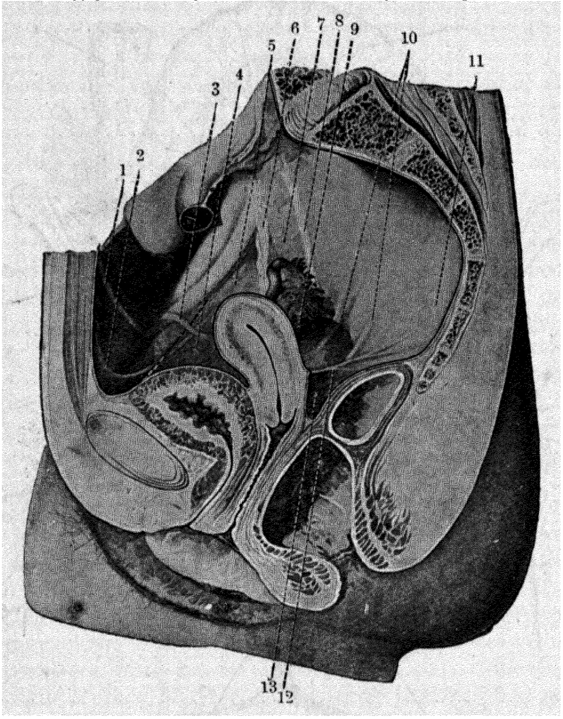

FIG. 138.—Mesial section of female pelvis, showing anatomy of parts in relation to rectum.—CUNNINGHAM.

1. Inferior epigastric artery.
2. Umbilical artery.
3. Round ligament.
4. Paravesical fossa.
5. Obturator fossa.
6. Ovarian vessels.
7. Obturator fossa.
8. Ureter.
9. Ovary.
10. Folds produced by nerve cords.
11. Pararectal fossa.
12. Utero-sacral fold.
13. Pouch of Douglas.

in the meso-rectum ligatured. The margins of the peritoneum in the floor of the pelvis are next sutured to the peritoneum covering the rectum, in order to shut off the peritoneal cavity and to help to fix the drawn-down rectum in position and assist in avoiding subsequent retraction. The divided margins of the levatores ani muscles are sewn together in front of and behind the rectum by the insertion of several points of chromicised catgut

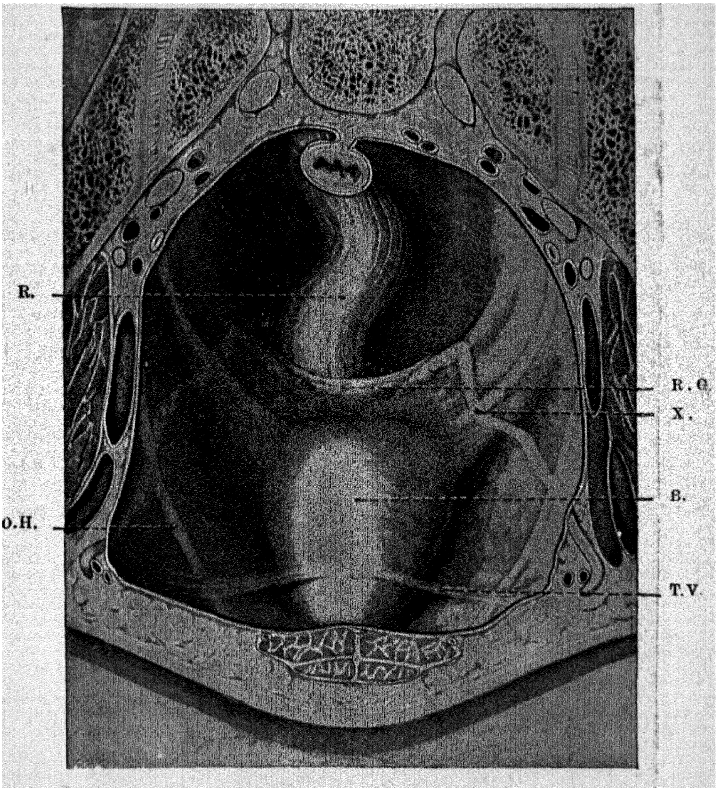

FIG. 139.—View of male pelvic viscera and rectum as seen from above. The pelvis has been sawn across obliquely.—BALL.

R. Rectum.
OH. Umbilical artery.
RG. Recto-genital fold of peritoneum.
X. Marks the point where the ductus deferens crosses the ureter.
B. Bladder.
TV. Transverse vesical folds.

suture, whilst the portions of these muscles opposite the lateral aspects of the rectum are fixed to the walls of the tube by careful suturing, perforation of the mucous membrane being avoided.

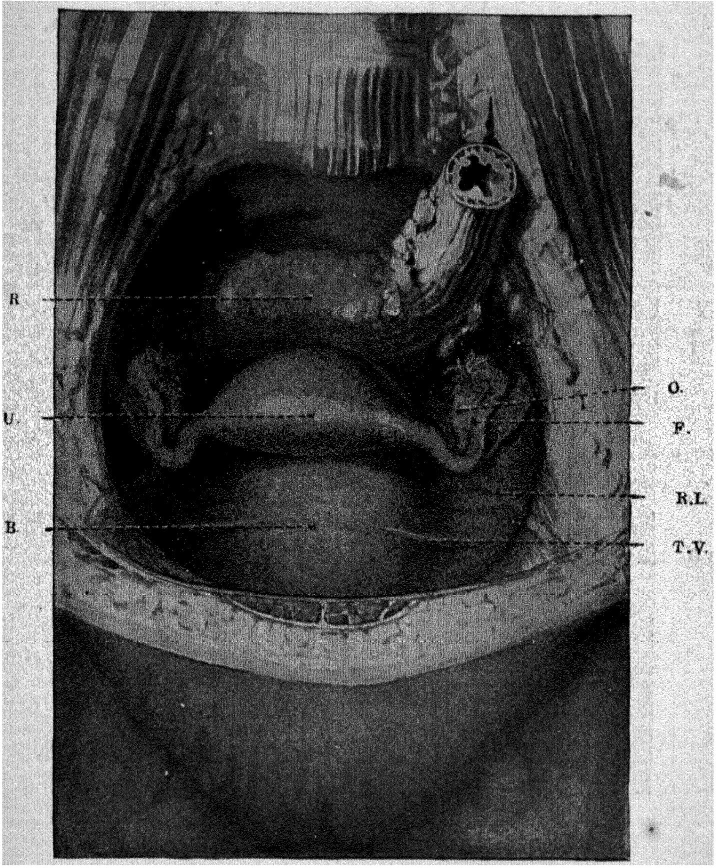

FIG. 140.—View of female pelvic viscera as seen from above.—BALL.

R. Rectum.
U. Uterus.
B. Bladder.
TV. Transverse vesical folds.
RL. Round ligament of uterus.
F. Uterine tube.
O. Ovary.

(*d*) *Removal of rectum and growth, and fixation of margins of* *cut upper extremity of bowel to skin region of former anus.*—The rectum having been well drawn down, a large intestinal clamp is placed upon it transversely to its long axis, and about 1½ or 2 inches above the upper limits of the diseased area. A second clamp is placed ½ inch distal to the first, and the section of the bowel is made between the two clamps by cutting across with a strong pair of scissors. The bowel and contained growth is thus removed. The clamp on the upper end of the divided rectum is loosened, and any bleeding vessels in the cut margin picked up and ligatured. Next, the divided margins of the intestine are carefully fixed to the margins of the skin in the region of the former anus by the insertion of a circle of silk sutures, each of which penetrates the entire thickness of the bowel.

(*e*) *Closure of external wound.*—With a large curved needle the margins of the incision in front of and behind the opening of the intestine are sewn together, by the insertion of a number of sutures of silk-worm gut, each suture passing sufficiently widely and deeply so as to include and approximate the divided external sphincter ani.

A large rubber tube is passed into the rectum, and a smaller tube into the posterior part of the incision for drainage, and dressings applied.

Excision of the rectum by the abdominal route.—*Indications.*—This method of operation is especially indicated when a carcinoma involves the upper portion of the rectum and the adjacent part of the pelvic colon, and the surgeon is unable to form a definite opinion as regards the extent of the diseased structures. It will occasionally happen, after the abdomen has been opened and the pelvis examined from above, that the surgeon decides that a radical operation for the removal of the diseased tissues is not feasible, in which case it may be considered necessary to establish a communication between the exterior and the lumen of the bowel on the proximal side of the growth by performing left inguinal colostomy.

Position.—The patient is placed in the dorsal position, and the pelvis raised. The operator stands on the left side of the patient, and his assistant directly opposite to him.

Operation.—(*a*) *Parietal incision.*—An oblique incision 3½ to 4 inches is made in the left inguinal region, and extending downwards from a point 1½ inches above and internal to the anterior superior iliac spine to the outer margin of the rectus abdominis muscle a little above the pubic spine. The muscular strata of the abdominal wall are divided as far as possible parallel with their fibres, and when the sheath of the rectus has been opened this muscle is retracted inwards. The inferior epigastric (deep epigastric) artery and vein are next sought for, as they cross the median portion of the incision and on the deep aspect of the muscles, isolated, ligatured in two places, and divided.

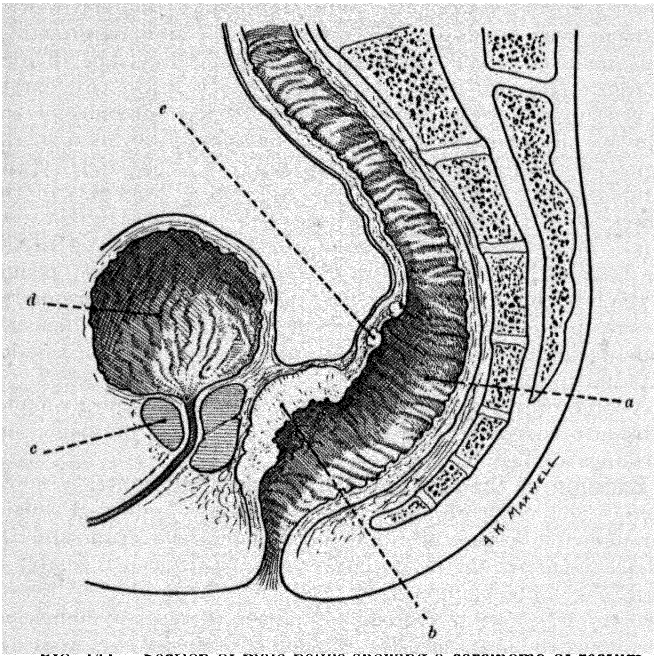

FIG. 141.—Section of male pelvis showing a carcinoma of rectum (ulcerating variety).

a. Rectum.
b. Carcinoma.
c. Prostate.
d. Urinary bladder.
e. Detached portion of carcinoma.

The peritoneum is next picked up, opened, and incised for the entire length of the wound. (The advantage of making an oblique incision of this kind is that the abdominal wall is not seriously weakened, and if it is found on investigation that the growth does not permit of local removal on account of its extensive connections, an inguinal colostomy can be performed by fixing a loop of intestine in the upper and outer part of the incision and closing the lower and inner parts by careful suturing.)

(*b*) *Exposure and removal of diseased portion of rectum.*—The peritoneal cavity having been opened, the coils of small intestine and the lower part of the great omentum which appear in the wound or lie in the pouch of Douglas are pushed upwards and towards the right, and kept in this position by packing with large flat gauze pads. The pelvic colon is next sought for, drawn upwards into the wound, and its lower portion and the upper portion of the rectum investigated and the extent of the disease ascertained, particular attention being paid to the lymph glands in the pelvic meso-colon and the meso-rectum, and the relations and connections of the growth to the adjacent structures. If it is decided to remove the growth, the affected portion of the bowel is brought well into the wound and freed from its surroundings by dividing the peritoneum on each side and blunt dissection with the finger or a dissector. Large intestinal clamps are applied about 1½ inches above and below the limits of the growth, and with strong scissors the intestine is cut through transversely, and the diseased segment taken away. Contamination of the surroundings by contents of the bowel must be avoided by careful emptying of the segment to be removed before the application of the clamps, and by protection with large flat gauze pads.

(*c*) *Union of divided ends of intestine.*—The diseased segment of intestine having been resected, the proximal and distal extremities of the divided bowel are brought into close approximation and joined together. If the upper segment cannot be readily brought into apposition with the lower without tension, the peritoneum on the outer side of the pelvic and iliac colon should be divided upwards into the left iliac fossa, when approximation can usually be effected without difficulty. Union of the two ends is best carried out by the insertion of sutures according to the method described in enterectomy (p. 122), but if the condition of the patient demands that the operation should be completed as quickly as possible, it may be done by using an "anastomosis button," or a "bone bobbin," reinforced by interrupted sutures introduced by Lembert's method. When union has been effected by one or other of these methods, the entire area of operation is sponged clean and dry, and the protecting pads and sponges removed.

(*d*) *Closure of external wound.*—This is carried out by the insertion of several tiers of superimposed sutures, the various strata being joined together layer by layer.

Excision of the rectum by a combination of abdominal and perineal methods.—Several forms of operation for removal of the rectum by a combination of the abdominal and perineal methods have been practised, and in well-selected cases give good results. The two operations which appear to me to be of the greatest value may be described as "*abdomino-perineal excision with the formation of an inguinal anus*," and "*abdomino-perineal excision with the formation of a perineal anus*." In each case the entire rectum and the pelvic colon are removed together with the fasciæ and peritoneum and lymph vessels and glands. When an inguinal colostomy opening is made, a larger amount of the pelvic colon can be excised than when the terminal aperture of the alimentary canal is left in the perineum. The former operation is recommended when the carcinomatous growth is situated in the lower portion of the rectum proper and has extended into the muscular walls of the gut or to the adjacent structures, and the latter when the neoplasm is located in the lower portion of the pelvic colon or upper portion of the rectum, and there is no extension of the growth to the surrounding structures.

Abdomino-perineal excision of the rectum with the formation of an inguinal anus.—*Position* (*first stage*).—The patient is placed in the Trendelenburg position, with the pelvis considerably raised. The operator stands on the left side of the patient, and the chief assistant on the right. A second assistant is directed to stand at the end of the operation table and to look after the large supra-pubic retractor.

Special Instruments.—Large supra-pubic retractor and abdominal retractors, or a large self-retaining abdominal retractor.

(*a*) *Parietal incision, examination of pelvic cavity, packing away abdominal viscera, division of colon, and separation of lower portion of colon and upper part of rectum.*—An incision is made in the middle line extending from the symphysis pubis to a little below the umbilicus. The different layers of the abdominal wall are divided and the peritoneal cavity opened. The coils of small intestines and the great omentum and transverse colon which hang down into or towards the pelvic cavity are pushed upwards and protected with large flat pads. The pelvic cavity and the position and extent of the growth are carefully examined, special attention being directed to the presence or absence of adhesions to adjacent structures, and to enlargement of the lymph glands in the pelvic meso-colon and on the lateral walls of the pelvis along the course of the hypogastric veins. If after examination it is decided that removal is feasible, the pelvic colon is lifted forwards into the parietal wound. A large supra-pubic retractor (Fig. 142) is placed in the lower part of the wound in order fully to expose the pelvic structures and so facilitate the further procedures, and the lateral margins also retracted with broad flat retractors (Fig. 143). The pelvic colon being thus fully exposed, the position of the branches from the inferior mesenteric artery are defined. A point in the pelvic colon midway between the upper and middle sigmoid branches of the inferior mesenteric artery is next determined, and a stout double silk ligature placed around the colon half an inch above and below this point, and each ligature firmly tied. Next the colon is divided transversely between these ligatures either with the knife of a thermo-cautery or by a strong pair of scissors. The cut margins which are left are now turned inwards towards the lumen of the bowel, and a purse-string suture inserted at each cut extremity and tied. By these means escape of intestinal contents and contamination of the

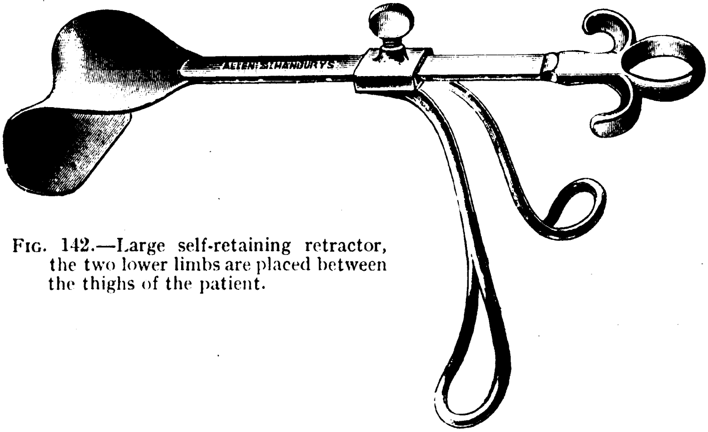

FIG. 142.—Large self-retaining retractor, the two lower limbs are placed between the thighs of the patient.

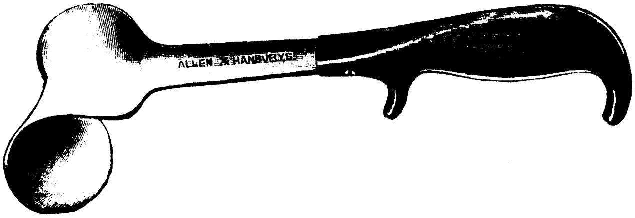

FIG. 143.—Large retractor for margin of parietal wound.

field of operation are avoided. The proximal segment of the bowel is surrounded with a gauze pad and packed away towards the left iliac fossa, until required later for the establishment of a colostomy opening. The pelvic meso-colon is then divided in a backward direction until the lower part of the main trunk of the inferior mesenteric artery is reached. This is ligatured at a point between the origins of the superior and middle sigmoid arteries, great care being taken to avoid the left ureter which lies immediately behind and parallel to the trunk of the artery, and then the remainder of the meso-colon is cut through. The parietal peritoneum on the posterior aspect of the pelvic cavity is now cut through on each side of the pelvic meso-colon and about 1 inch from it, these incisions being prolonged down-

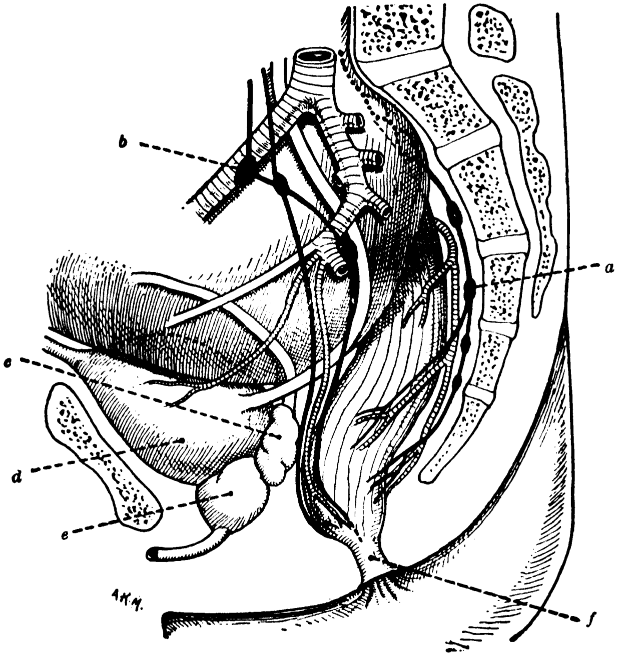

FIG. 144.—Diagrammatic and schematic section of male pelvis, showing relations of rectum to structures adjacent.

a. Lymph gland in hollow of sacrum.
b. Lymph gland at division of hypogastric artery.
c. Vesicula seminalis.
d. Urinary bladder.
e. Prostate.
f. Anal canal.

wards and forwards across the pouch of Douglas until they meet in front immediately behind the posterior part of the base of the bladder. In the female it may be necessary to remove the left ovary and uterine tube. The parietal peritoneum on each side is next separated upwards and outwards for some distance by blunt dissection, so as to facilitate separation of the rectum and also at a later period restoration of the pelvic diaphragm.

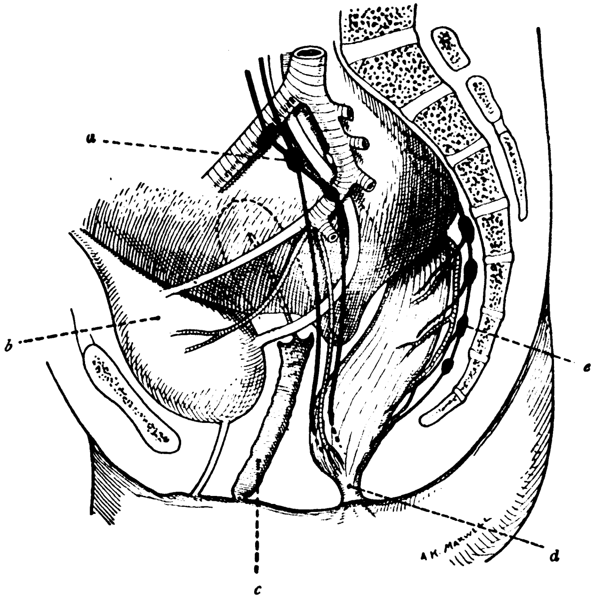

FIG. 145.—Diagrammatic and schematic section of female pelvis, showing relations of rectum to structure adjacent.

a. Lateral pelvic lymph glands.
b. Urinary bladder.
c. Vagina.
d. Anal canal.
e. Sacral lymph glands.

The lower segment of the alimentary canal can now be readily separated from its posterior and lateral attachments by blunt dissection downwards and forwards. Little or no hæmorrhage will be met with, since the main blood supply has already been controlled by ligature of the inferior mesenteric above. The separation is commenced at the level of division of the meso-colon, and is continued along the posterior and lateral walls of the pelvic cavity in such manner that the detached portion of the pelvic colon and its attached meso-colon, the parietal peritoneum on each side of this meso-colon on the posterior and inferior aspects of the pelvic cavity, the fasciæ from the same regions, and the lymph vessels and lymph glands, are detached in one continuous mass as far as the upper aspect of the muscular pelvic diaphragm formed by the levatores ani muscles. In front a similar process of blunt dissection is

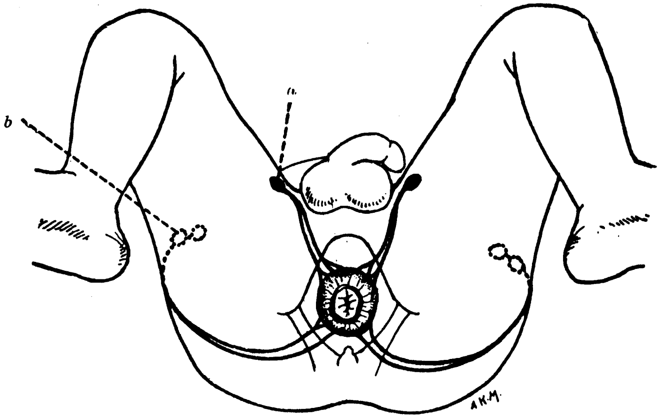

FIG. 146.—Male perineum. Course of lymph vessels and position of lymph glands receiving vessels from perineum.

a. Superficial external inguinal lymph glands.
b. Superficial internal inguinal lymph glands.

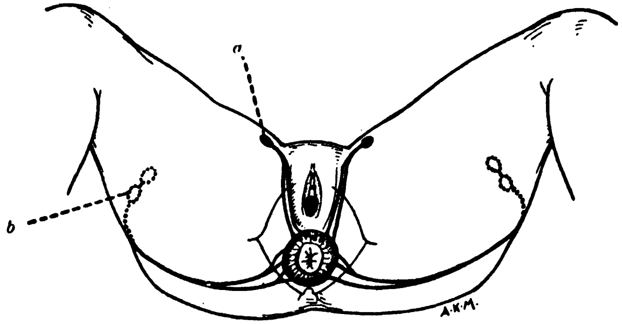

FIG. 147.—Female perineum. Course of lymph vessels and position of lymph glands receiving lymph vessels from perineum.

a. Superficial external inguinal lymph glands.
b. Superficial internal inguinal lymph glands.

adopted in order to detach the anterior aspect of the rectum from the posterior and inferior aspects of the bladder. It is very essential when freeing the lateral connections on the left side of the pelvis, that a sharp lookout be kept for the left ureter in order to avoid injury to this tube. It will be found closely adherent to the parietal peritoneum on the left lateral wall of the pelvis. The blunt dissection posteriorly along the hollow of the sacrum and coccyx, and anteriorly between the bladder and rectum, can readily be effected with the index-finger, but laterally it will be necessary to cut through strong processes of the pelvic fascia—the lateral fascial ligaments of the rectum, —when the upper aspect of the levatores ani muscles have been reached. This division of fasciæ should be carried out by cutting with a strong pair of scissors. Afterwards the separation is carried on until the distal portion of bowel is quite free on all sides as far as the pelvic diaphragm. This separation having been effected, the distal segment of the alimentary canal is pushed downwards towards the pelvic outlet, together with the attached meso-colon, fasciæ, etc., and covered with a thin gauze pad. The operator should be very careful to make the separation as described, so that no unnecessary difficulties may be encountered when the perineal portion of the procedure is being carried out.

(*b*) *Re-establishment of the peritoneal pelvic diaphragm, formation of a colostomy opening, and closure of the abdominal parietal wound.*—The margins of the flaps of parietal peritoneum which were dissected free on each side of the pelvis are now approximated and fixed by the insertion of a continuous suture of No. 2 chromicised catgut. Some difficulty may be experienced in completely closing in the space anteriorly, but often the peritoneum upon the posterior aspect of the bladder in the male, and the uterus in the female, can be utilised for this object. An incision 1½ inches long is next made through the skin of the anterior abdominal wall, and placed at right angles to a line drawn from the anterior superior iliac spine on the left side to the umbilicus, and 1½ inches medial to the spine. This incision is carried through the entire thickness of the abdominal wall, each muscular stratum being divided parallel to the direction of its fibres as in inguinal colostomy (p. 147). Through the opening thus made the sewn-up extremity of the proximal segment of the pelvic colon, which had been placed aside in the left iliac fossa at an earlier stage of the operation, is drawn with a large pair of intestinal forceps. The margins of this terminal extremity are then attached to those of the parietal wound by a few points of catgut suture. All sponges and pads are now removed from the peritoneal cavity, and the entire area of operation sponged with warm saline solution, in order to remove any blood clot, etc. The coils of small intestine, the large omentum, and the median portion of the transverse colon and the cæcum are replaced in their usual positions, and the parietal wound between the symphysis pubis and umbilicus closed in the usual manner by the insertion of three tiers of sutures. Dressings are applied, or the anterior abdominal wall covered with large pads, which are held in position by an assistant during the second stage or perineal stage of the operation.

Position (*second stage*).—The operation table is lowered so as to make the table flat, and the patient placed in the right lateral and semi-prone position, or in the lithotomy position, the former usually being found to be the most convenient.

(*c*) *Closure of anal opening, skin incisions, and separation of distal segment of bowel.*—A strong silk purse-string suture is inserted around the anal aperture and tied tightly, so as to avoid contamination of the area of operation. The skin of the perineum is painted with iodine, or otherwise made as aseptic as possible by washing with ether, spirit and biniodide of mercury 1–500, etc. An incision is then made through the skin, which commences first over the coccyx and extends forwards for a short distance towards the anus, then surrounds the anal opening by a large oval sweep, and is prolonged forwards well into the perineum a little in front of the central point. The skin and underlying fat and fascia are dissected outwards on each side for some distance, and then the cut is deepened until the lower aspect of the levator ani muscle is reached on each side. This muscle is cut through, the fascial and ligamentous structures attached to the apex of the coccyx divided, and then the bowel and attached meso-colon, etc., is pulled downwards from the pelvis. Nothing now remains to fix the bowel except its attachments anteriorly to the region of the prostate in the male, and the posterior aspect of the vagina in the female. These attachments are fascial in character and can readily be cut through with a strong pair of scissors. All bleeding points are next picked up and ligatured. By these means the bowel is freed and removed.

(*d*) *Obliteration of space in outlet of pelvis and closure of perineal wound.*—All hæmorrhage having been completely arrested on the sides of the pelvic outlet, the entire area is washed or sponged with hot saline solution. Next, the margins of the deep part of the wound are approximated as far as possible by the insertion of deep sutures of catgut, and in this manner the pelvic diaphragm partially reconstituted and strengthened from below.

Finally, the margins of the skin flaps are brought into apposition and fixed by the insertion of strong salmon-gut sutures. A small portion of the perineal wound should be left open posteriorly, and a rubber drainage tube of moderate size passed into the space in the hollow of the sacrum. If this is not done, a " dead space " is often left where an effusion of blood or serous fluid may readily collect and become a source of septic trouble at a later period. Dressings are now applied to the perineal wound and fixed in position by a T-bandage. The patient is now turned over into the dorsal posture, and dressings applied to the abdominal wounds if these have not been already done. The closed extremity of the pelvic colon which was fixed in the colostomy incision can either be left until the next day, or it can be opened by removing the purse-string suture, and placing in the aperture a small rubber tube. This tube should be fixed to the margins of the opening of the bowel, so as to prevent septic contamination of the margins of the parietal wound to which the bowel has been attached.

Abdomino-perineal excision of the rectum with formation of a perineal anus.—The main stages of this operation are similar to those described in the paragraphs dealing with " Abdomino-perineal excision of the rectum with formation of an inguinal anus," essential differences being, a left inguinal colostomy is ***not*** made, and the open extremity of the proximal portion of the bowel is fixed to the skin in the region of the former anus.

Special instruments.—Large abdominal and pelvic retractors.

Position (*first stage*).—The patient is placed in the dorsal posture and the operation table raised to the "high Trendelenburg position." The operator stands on the left side of the patient, the chief assistant opposite to him, and a second assistant at the end of the table. The duty of the second assistant is to look after the large retractor. When a second assistant is not available, a large self-retaining retractor (Fig. 142) should be used.

Operation.—(*a*) *Parietal incision, investigation of pelvic and abdominal cavities, determination of position and extent of primary disease, search for and location of enlarged lymph glands in pelvis and pelvic meso-colon.*—An incision is made through the anterior abdominal wall, commencing at the upper margin of the symphysis pubis and extending upwards to just below the umbilicus. This incision divides the various strata of the anterior abdominal wall, and the peritoneal cavity is opened. Next the great omentum, coils of small intestine, cæcum and transverse colon, if they occupy a portion of the pelvis, are pushed upwards and packed away by covering them with a thin large flat gauze pad.

The course of the pelvic colon and upper portion of the rectum are carefully investigated so as to determine as far as possible the position of the neoplasm, the extent of bowel involved, and the invasion of adjacent structures, if any. The presence of a tumour in the course of the bowel, induration of its walls, adhesion to adjacent structures and amount of fixation are the chief points to which attention should be directed in making this investigation. Next, the pelvic meso-colon is carefully palpated in order to determine the presence of enlarged lymph glands. The usual position of these lymph glands is shown in Figs 144 and 145. The lateral walls of the pelvis and the hollow of the sacrum are also carefully examined in order to determine the condition of the lymph glands in these areas. The usual position of these glands is also shown in Figs 144 and 145. When the lymph glands are not extensively enlarged, the lateral pelvic glands are not adherent to the adjacent veins, and the position and connections of the primary neoplasm are favourable, then removal of the disease can be decided upon. The exposed aspect of peritoneum should also be carefully examined for small detached nodules of secondary growth in the subperitoneal tissue, since, when present, they contra-indicate radical operation. Before proceeding further it is always desirable to palpate the lymph glands in front of the lumbar portion of the spinal column and also the liver, in order to exclude all gross evidence of secondary growths in these situations, since, if signs of secondary growths are found either in the lumbar lymph glands or in the liver, it must at once be determined to abandon the complete operation, and to consider the advisability or non-advisability of performing a palliative left inguinal colostomy. As a general rule this is advisable, especially when the lumen of the affected portion of the gut is partially obstructed by the growth. The performance of this operation will obviate the onset of an attack of acute intestinal obstruction due to obliteration of the lumen of the large intestine at the seat of disease, and will enable the patient to be kept more comfortable by allowing periodical washing out of the rectum and lower segment of the pelvic colon from above.

(*b*) *Incision of parietal pelvic peritoneum, ligature of lower part of inferior mesenteric artery, and separation of bowel and attached meso-colon, pelvic fascia and lymph glands to upper aspect of pelvic diaphragm, partial reconstruction of peritoneal pelvic diaphragm by suture of margins of peritoneal incisions, peritoneal toilet, and closure of abdominal wound.*—A longitudinal incision is made through the parietal pelvic peritoneum 1 inch from each side of the base of the pelvic meso-colon, and continued downwards and forwards across the pelvic cavity until the two limbs meet on the posterior aspect of the urinary bladder, by making each curve inwards. In the case of the female the left broad ligament should be divided, and the ovary and uterine tube removed. The lower portion of the trunk of the inferior mesenteric artery as it lies in the base of the pelvic meso-colon is exposed by dissection and then ligatured usually just beyond the second sigmoid branch. The accompanying vein is treated in a similar manner. Next, the parietal pelvic peritoneum on the outer side of each longitudinal incision is dissected up from the underlying tissues for about 1 inch on each side towards the lateral pelvic wall. When this has been accomplished, the distal portion of the pelvic colon, the upper portion of the rectum, the pelvic meso-colon, the portions of pelvic fasciæ and contained lymph vessels and glands, can be separated with the forefinger or a blunt dissector until they are freed from their connection as far as the upper aspect of the converging levatores muscles. When effecting this separation it will be necessary to divide the pelvic fascia on each side as it leaves the lateral wall of the pelvis with a pair of strong scissors. During the process of detachment, especial care must be directed to avoid injury to the left ureter, which will be found lying upon the postero-lateral pelvic wall behind the parietal peritoneum in the region of the inferior mesenteric blood vessels. The bowel having been thus separated from its surroundings now remains continuous above with the iliac colon, and below with the lower segment of the rectum, and has attached to it the pelvic meso-colon, portions of parietal pelvic peritoneum fasciæ and lymph glands. It is pushed downwards, together with the attached structures, into the bottom of the pelvic cavity, and the margins of the divided pelvic peritoneum approximated and fixed in close apposition by careful suturing with catgut. A continuous suture with several fixation interruptions will be found to be the most convenient. On each side also the peritoneum is sutured to the lateral aspects of the pelvic colon. Anteriorly some difficulty may be experienced in effecting complete apposition, but usually this can be avoided by dissecting up some of the peritoneum on the posterior aspect of the bladder, and in the female the posterior aspect of the uterus may be made use of for closing in the deficiency. The peritoneal pelvic diaphragm having been thus reconstructed, the protecting gauze pads are removed and the area of operation sponged with hot saline solution, the large omentum and attached transverse colon, and coils of small intestine are allowed to fall or are placed in their usual position, and finally the parietal abdominal wound is closed by the insertion of three superimposed tiers of sutures, according to the method already described.

Position (*second stage*).—The operation table is lowered from the raised pelvic position, and the patient placed in the semi-recumbent posture and lying on his right side. The operator stands opposite the pelvic outlet, one assistant opposite to him, and a second on his right hand. The left buttock is raised by the assistant, and the region of the perineum again sterilised by painting with iodine or other method. The skin at the anal margin is divided around the aperture, and sewn up tightly in order to shut off completely the canal of the bowel from the field of operation. Next, the incision is prolonged backwards towards the tip of the coccyx, and deepened until the lower aspect of the pelvic diaphragm is reached. The lower portion of the rectum, including the internal sphincter, is then dissected free from its anterior and lateral connections until the anal fascia lying upon the inferior aspect of the levator ani on each side is exposed. This dissection may be facilitated in the male by passing a metal sound along the course of the urethra into the bladder. With a strong pair of scissors the anal fascia and levator ani muscle on each side are cut through until the space within the pelvis is opened up in which lie the bowel, etc., which have been separated from above. The hand is introduced into this space, and the rectum, pelvic colon, and attached structures are drawn downwards, any connective tissue connection which has not already been divided being cut through. The lateral walls of the bowel are then attached to those of the divided pelvic fasciæ and muscles by a few points of catgut suture, commencing above in the depths of the perineal wound, and finishing immediately above the site of the former anus. A rubber drainage tube of moderate calibre is passed through the posterior part of the perineal wound into the hollow of the sacrum. There is usually a considerable amount of unobliterated " dead space " here, which, if not drained, will serve as a site for collection of blood and serum. This exudation is prone to become infected and suppuration follow, an unpleasant complication which can usually be avoided by the establishment of free drainage. A purse-string suture is now passed around the bowel just beyond the level where it has been decided to divide it, and then transverse division is effected either with the knife of a thermocautery, or strong scissors. A rubber drainage tube is next passed into the lumen of the bowel from below, and the purse-string suture tightened sufficiently to retain the tube in position and also prevent escape of the contents of the bowel. The skin at the margin of the former anus is finally sutured to the circumference of the distal end of the bowel close to the purse-string suture, and any portion of the posterior portion of the perineal wound which is not required for the drainage tube closed by careful suturing. The parts in the field of operation are painted with iodine, and dressings applied. When the alimentary canal has been thoroughly emptied by purgatives before the operation, it is sometimes advisable to entirely close the distal end of intestine by the introduction of a purse-string suture instead of placing a drainage tube in the outlet. Under favourable conditions this can be left closed for two or three days before making an opening. In my experience, however, better results are obtainable by the use of the drainage tube.

Excision of rectum by vaginal route.—*Indications.*—This operation is indicated when a carcinoma involves the portion of the rectum adjacent to the vagina and extends upwards as far as the peritoneal reflection, but does not extend too widely to contra-indicate local operation, and is not associated with secondary growths elsewhere.

Position.—The patient is placed in the lithotomy position, the pelvis being slightly raised. The surgeon sits opposite the perineum, and an assistant stands on each side of him.

Special instruments.—Wide retractors, tenaculum forceps, and sharp hooks.

Operation.—Excision of the rectum by the vaginal route can be conveniently divided into the following stages :—

(*a*) *Vaginal and perineal incisions, and exposure of diseased area.*—The vagina is widely dilated with retractors, and the exact extent and connections of the growth ascertained. The anterior portion of the cervix uteri is seized with tenaculum forceps, forcibly drawn downwards and forwards, and held in this position by an assistant. A transverse incision is next made through the posterior vaginal wall at the bottom of the posterior fornix and the peritoneal cavity opened, the exposed portion of the cavity being packed with strips of gauze or flat gauze pads so as to prevent escape of the intestines and keep them out of the way. A longitudinal incision is next made through the posterior vaginal wall and the perineum, from the middle of the transverse incision to the anterior margin of the anus, and a flap dissected up upon each side so as to lay bare the anterior aspect of the rectum, care being taken not to open the rectal canal. If any portion of the vaginal wall is involved in the carcinomatous growth, an elliptical incision must be made instead of the longitudinal one, in order to include the diseased area.

The mucous membrane of the lowest portion of the rectum is now separated from the surrounding tissues by blunt dissection, and surrounded by a strong silk ligature immediately above the anus, so as to prevent escape of rectal contents and contamination of the field of operation by them during the succeeding stages.

The lateral aspects of the rectum are next freed by dissection with the scalpel or cutting with scissors, and in the upper part of the wound the rectum is pulled downwards and forwards, and the incision in the peritoneum continued backwards as far as the sacrum on each side, cutting through the peritoneum forming the lateral reflection from the rectum to the meso-rectum. By these procedures the rectum is loosened, and can readily be separated from its connections with the sacrum and overlying fascia, whilst the lymph glands which lie upon the anterior aspect of the sacrum may be removed.

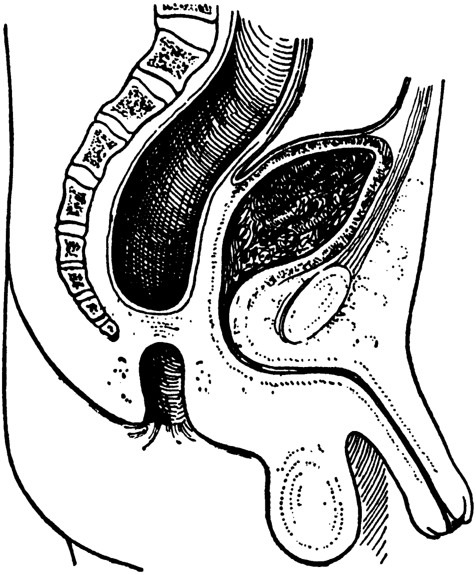

FIG. 148.—Vertical section through pelvis, showing imperforate rectum. Anus well formed, but ending in a cul-de-sac.

(*b*) *Removal of rectum and carcinomatous growth, and suture of upper end of divided intestine to region of former anus.*—The deep portions of the wound are packed with gauze in order to prevent prolapse of the intestines; the rectum is further drawn forwards and downwards, and separated from its posterior and lateral connections, which have not yet been divided. Next, two large intestinal clamps are placed on the rectum, the upper at least 1½ inches above the upper limit of the growth, and the lower ½ inch nearer the diseased portion, and the bowel divided transversely between them, care being taken to avoid escape of bowel contents. Each cut end of rectum is covered with a piece of gauze immediately after section. The lower segment is then pulled forwards and separated until the place where the mucous membrane has been surrounded with a silk ligature is reached, when the bowel is again cut through on the distal side of the ligature and the segment thus set free removed.

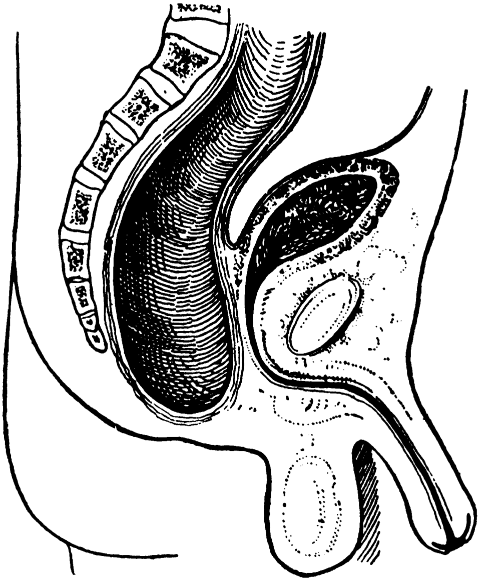

FIG. 149.—Vertical section through pelvis, showing imperforate anus.—BALL.

All bleeding points are then arrested by the application of ligatures, and the bowel above pulled downwards towards the anus, the gauze packing removed, and the anterior and lateral openings in the peritoneum closed by suturing with chromicised catgut. The free margins of the bowel thus brought down are now approximated and fixed to the skin at the margins of the anus by the insertion of a ring of silk sutures. In addition, the lateral aspects of the bowel are sutured to the tissues adjacent to them—the inner aspects of the sphincters and the pelvic diaphragm—by a few interrupted sutures of chromicised catgut. Finally, the divided external sphincter, the margins of the incisions in the perineum, and the posterior vaginal wall are sutured together by the insertion of interrupted sutures of chromicised catgut. A large tube is placed in the rectum, and dressings applied.

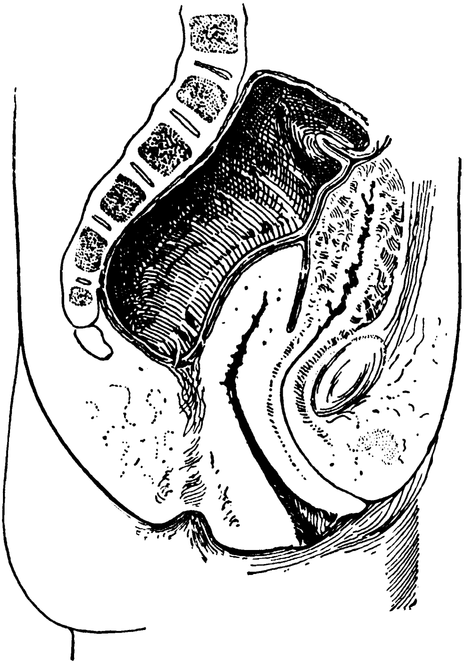

FIG. 150.—Vertical section through pelvis, showing absence of lower part of rectum. The anal dimple is present.—BALL.

When there has been much hæmorrhage or a large amount of tissue has been removed, it is usually necessary to make an incision through the skin in front of the tip of the coccyx, and to pass a rubber drainage tube into the region of the hollow of the sacrum.

This operation in well-selected and suitable cases has been followed by good results, whilst the rate of mortality from the operation is small.

Operation for imperforate rectum and anus.—The object of this operation is to establish a communication between the rectum and the perineal surface in those cases in which this is congenitally absent.

Indications.—The indication is the inability of the infant to defæcate, owing to the presence of a congenital malformation or deficiency, this defect existing with or without the presence of recto-vaginal or recto-vesical fistulæ.

Special instruments.—Small speculum, trocar and cannula.

Operation.—The patient is placed in the lithotomy position. If an anus be present, the speculum is introduced and the cavity of the rectum examined (Fig. 148). Should a membranous diaphragm be the only obstruction in the lumen of the rectum or at the anus, this is perforated with a trocar or scalpel, and the condition thus relieved. Otherwise the anal aperture must be dilated or enlarged, and careful dissection in the middle line pursued till the bulging lower bowel is found, which is then opened with the trocar or scalpel.

In those cases where no anus or anal dimple indicates the position of the perineal termination of the bowel, a median incision 1 or 2 inches in length, and extending from the anal dimple, if present, or if not, from the anterior portion of the perineal region, backwards to a point overlying the apex of the coccyx, must be made, and the dissection conducted thence inwards till the bowel is found (Figs. 149 and 150). When this has been done the lower extremity is incised.

There is no object in attempting to unite the mucous membrane of the bowel and the anus. The after-treatment necessitates the continued passage of bougies till stenosis no longer threatens.

Cases in which the attempt to find the bowel and establish an opening proves ineffectual must be relieved by the performance of a left inguinal colostomy.

CHAPTER V

OPERATIONS FOR THE CURE OF HERNIA

1. Operation for the Radical Cure of Inguinal Hernia.
2. Operation for the Radical Cure of Femoral Hernia.
3. Operation for the Radical Cure of Umbilical Hernia.
4. Operation for Strangulated Hernia.
    - Inguinal hernia.
    - Femoral hernia.
    - Umbilical hernia.
    - Obturator hernia.

Operation for the Radical Cure of Inguinal Hernia

Numerous operations have been devised for the cure of an inguinal hernia. Some of them are very complicated, whilst others are correspondingly simple. The operation which I shall describe is one I have found the most efficient and at the same time easy of performance. It is a modification of Bassini's operation.

Indications.—(*a*) Most cases of irreducible inguinal hernia.

(*b*) Those cases of strangulated hernia which are operated upon for the relief of strangulation, and in which it is safe to perform a somewhat prolonged operation.

(*c*) Cases of reducible hernia in children and young people, in order to obviate the wearing of a truss. A number of other indications might be given, but for a discussion of these the student is referred to a text-book of surgery.

Position.—The patient is placed in the dorsal posture; the surgeon stands on the affected side of the patient, and his assistant directly opposite to him.

Anatomical considerations.—The inguinal canal is a potential space lying between the different strata of the anterior abdominal wall, which commences internally at the abdominal inguinal ring (internal abdominal ring)—an aperture in the fascia transversalis—and terminates at the subcutaneous inguinal ring (external abdominal ring)—an aperture in the external oblique muscle. It is bounded *anteriorly* by the external oblique for its entire extent, and by the attachment to the inguinal ligament (Poupart's) of the innermost fibres of the internal oblique for the external ½ inch; *posteriorly*, by the fascia transversalis for the entire extent; and behind this, the inferior (deep) epigastric vessels externally; and then, in succession, the middle inguinal pouch, the umbilical artery (obliterated hypogastric), and the

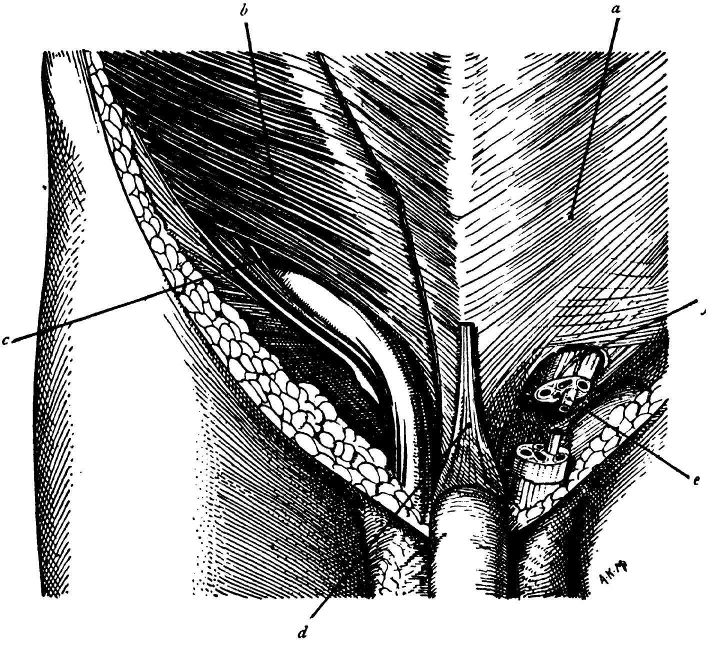

FIG. 151.—Dissection of inguinal regions, showing structures met with in the operation upon an inguinal hernia.

a. External oblique.
b. Internal oblique.
c. Position of internal abdominal ring.
d. Suspensory ligament of penis.
e. Ductus deferens.
f. Spermatic cord.

lateral part of the internal inguinal pouch. Internally, in front of the fascia transversalis, is the falx aponeurotica (conjoined tendon) of the internal oblique and transversus abdominis. The *floor* of the canal is formed by the grooved upper surfaces of the inguinal (Poupart's) and lacunar (Gimbernat's) ligaments. The *roof* is formed by the arching fibres of the internal oblique and transversus. The contents of the canal in the male are the constituents of the spermatic cord, together with the coverings of this structure which are derived from the fascia transversalis and the internal oblique. These are known as the infundibuliform fascia and the cremaster muscle respectively. The inguinal branch of the ilio-inguinal nerve lies in the superficial part of the canal, and emerges through the subcutaneous inguinal ring (external abdominal ring).

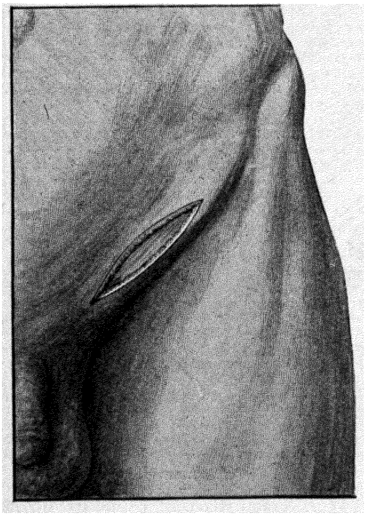
FIG. 152.—Inguinal hernia. Radical cure. Position of external incision.

In the female the inguinal canal contains the round ligament of the uterus, and the process of peritoneum known as the canal of Nuck, together with coverings similar to those of the spermatic cord.

Operation.—The operation may be divided for convenience of description into the following five stages:—

(*a*) *Skin incision and exposure of eternal oblique and external abdominal ring with a portion of the hernial sac.*—An incision is made from 2½ to 3 inches long, which commences ½ inch internal to the pubic spine and over the middle point of the pubic crest, and extends upwards and outwards parallel with but a little above the line of the inguinal ligament (Poupart's) (Fig. 152). This incision is made to divide the skin, superficial and deep fascia, with their contained superficial external pudendal and superficial epigastric vessels, and to expose the external surface of the external oblique muscle, which is readily recognised by the whiteness of its tendinous fibres and the semicircular arrangement of the intercolumnar fibres. When this has been done, the skin and subcutaneous tissues are dissected upwards from the surface of the external oblique muscle for a short distance, so as fully to expose the muscle and also the aperture of the subcutaneous inguinal (external abdominal) ring, and that portion of the hernial sac which protrudes through it.

(*b*) *Incision of external oblique, opening of inguinal canal, exposure of hernial sac and its contents.*—The external oblique aponeurosis is divided for the length of the first incision. The incision commences at the apex of the subcutaneous inguinal (external abdominal) ring, and extends upwards and outwards parallel with the direction of the fibres of the muscle. The lower incised margin of the external oblique is then pulled downwards with a retractor, so as to expose the entire inguinal canal together with its contents. These are, in the male, the spermatic cord with some of its coverings, the hernial sac and its contents ; in the female, the round ligament of the uterus, the hernial sac and its contents. The coverings of the spermatic cord within the inguinal canal—the cremasteric muscle and fascia and the infundibuliform fascia—are divided in a line corresponding to the

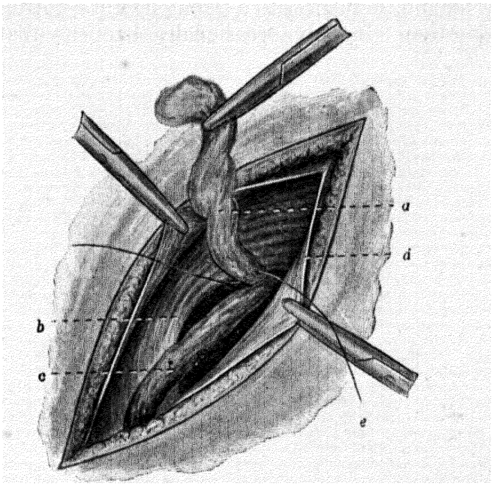

FIG. 153.—Inguinal hernia. Inguinal canal opened and sac separated, twisted and transfixed.

a. External oblique.
b. Conjoined tendon of internal oblique and transversus abdominis (transversalis).
c. Spermatic cord.
d. Hernial sac.
e. Suture passed through neck of sac.

direction of the inguinal canal, and then the hernial sac is carefully opened with the scalpel, the wall of the sac being picked up with dissecting forceps, and its visceral contents (omentum, intestine, etc.) returned into the abdominal cavity. In cases of irreducible hernia, the cause of the irreducibility—such as adhesions, the presence of a large quantity of herniated omentum—must be dealt with before attempting to reduce the herniated viscus. Thus adhesions must be tied in two places and cut between, whilst in the case of large pieces of omentum it is best to transfix and tie them with a strong ligature, cutting away the distal portion. It only occasionally happens that, in non-strangulated herniæ, it is requisite to divide the neck of the sac in order to return the herniated structures.

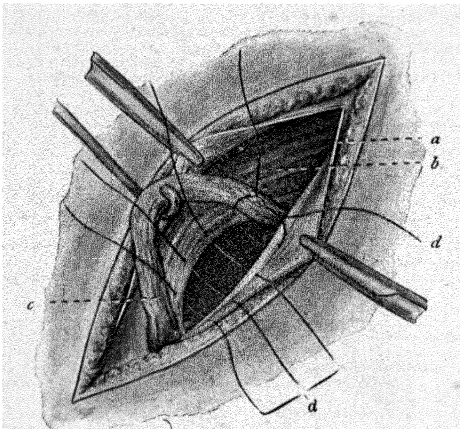

FIG. 154.—Radical cure of inguinal hernia. Closure of inguinal canal.

a. External oblique.
b. Lower portion of falx aponeurotica (conjoined tendon) of internal oblique and transversus abdominis.
c. Spermatic cord.
d. Deep sutures passing through grooved upper aspect of the inguinal ligament (Poupart's ligament) and lower fibres of the falx (conjoined tendon).

(*c*) *Treatment of hernial sac.*—The hernial sac is now separated by careful dissection from the constituents of the spermatic cord, especial care being taken not to cut or divide the ductus (vas) deferens, a structure which can readily be recognised by its hard cord-like feel. This separation must extend downwards from the margins of the deep inguinal ring, at the outer extremity of the incision, to the bottom of the sac. When the hernia is of the congenital variety, it will be found to be continuous below with the tunica vaginalis testis. In this latter case the sac is transfixed a little above the testis, and tied with a ligature of chromicised catgut. Next, a clamp is placed a little above the point of transfixion, and the sac cut through with scissors, on the distal side of the clamp and on the proximal side of transfixion. The hernial sac can now be lifted up, when it is seen to be quite free up to the internal abdominal ring. It is twisted upon itself, traction exerted upon it, and then transfixed as high up as possible with a needle armed with a strong ligature. This ligature is then tied—the two halves separately—and the distal portion of the sac removed (Fig 153). When this has been properly done, the site of the former abdominal inguinal ring and neck of the hernial sac is represented by a little prominence of peritoneum on the deep aspect of the anterior abdominal wall. There is thus no depression which might favour a recurrence of the hernial protrusion.

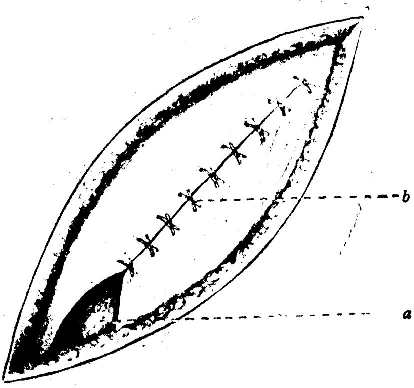

FIG. 155.—Radical cure of inguinal hernia. Closure of incision in external oblique.

a. Spermatic cord.
b. Sutures closing incision in external oblique.

(*d*) *Obliteration of inguinal canal.*—The constituents of the spermatic cord are lifted up by an assistant with a retractor, and with a curved hernia needle or a fully curved needle of medium size a series of sutures is passed through the lower margin of the falx aponeurotica (conjoined tendon) of the internal oblique and transversus, and the recurved edge of the inguinal (Poupart's) and lacunar (Gimbernat's) ligament; usually four or five are sufficient. After all these have been introduced they are tied and their ends cut short. The spermatic cord is then placed on the superficial aspect of the conjoined tendon (falx), in what may be called a new inguinal canal (Fig. 154).

(*e*) *Suture of external oblique and skin.*—The margins of the incision in the external oblique are approximated and fixed together by the insertion of a row of fine silk sutures (Fig. 155), care being taken to avoid including the inguinal branch of the ilio-inguinal nerve in one of the sutures. The wound is then sponged dry, and the margins of the parietal incision fixed together by a row of salmon-gut sutures.

Especial care should be taken to apply ligatures to the cut proximal ends of the superficial epigastric and superficial external pudendal arteries. If this is not done, a hæmatoma in the superficial part of the wound is likely to result, which can only be cured by opening up the wound, finding the bleeding vessels and ligaturing them.

Bassini's operation (radical cure of inguinal hernia).—This operation in the main corresponds to the above, with the exception that the lower portion of the internal oblique is divided for about half an inch; so as fully to expose the position of the deep or internal abdominal ring.

OPERATION FOR RADICAL CURE OF FEMORAL HERNIA

Several varieties of operation have been recommended for the radical cure of a femoral hernia. It is doubtful, however, if any of them can be regarded as certain in their results, since recurrence is fairly common after their performance if the patient does not wear some form of truss or support. There is no doubt, however, that the performance of an operation, such as the one described later, often cures a femoral hernia, and in severe cases in which there is a large femoral (crural) ring with attenuated aponeurotic and fascial surroundings, facilitates the retention of the hernial swelling, and allows the patient to wear a lighter form of truss.

Position.—The patient lies in the dorsal position, with the limb of the affected side slightly flexed, abducted, and rotated outwards, a pillow being placed under the knee. The surgeon stands on the affected side of the patient, and his assistant on the opposite one.

Operation.—The operation may be divided into four stages, which are—

(*a*) *External incision and exposure of sac.*—An incision is made either obliquely or in the long axis of the hernial swelling, commencing in front of the inguinal (Poupart's) ligament, outside the pubic spine, and extending downwards for about 2 inches (Fig. 156). The skin, superficial fascia, cribriform fascia, and the fascia of the femoral sheath are divided, and the superficial aspect of the hernial sac exposed. This can be recognised by its tenseness, its slaty-blue colour, the arrangement of the blood vessels upon its surface—these are said to be arborescent—and by the fact that the sac itself can be picked up, and made to glide over the contents. The sac is carefully divided almost up to the femoral (crural) ring. The surgeon can often recognise that he has divided the sac wall by the escape of a quantity of clear fluid (blood-stained in the case of a strangulated hernia). The contents of the sac are next examined, and dealt with as may be necessary. If any adhesions are met with, they are separated either by breaking them down with the finger if they are recent, or by division and ligature if of old standing.

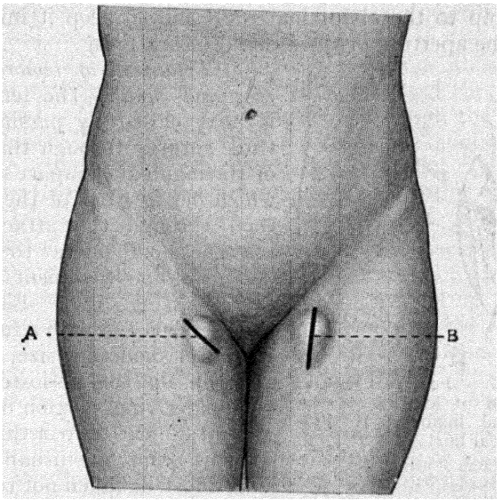

FIG. 156.—Femoral hernia.

A. Oblique form of incision. *B*. Vertical form of incision.

(*b*) *Treatment of sac.*—When the sac has been exposed and opened, and the contents returned into the abdominal cavity, its neck is well separated with the finger from the surrounding tissues about the femoral (crural) ring. Traction is exerted upon it, and a ligature applied around its neck as high as possible. If the sac is small the ligature may simply surround the neck, but in most instances it is advisable to transfix it as high as possible, and to tie it in two halves, as in the case of inguinal hernia. When these ligatures have been tied the ends are kept long, and the sac removed beyond the line of application of the ligature, sufficient being left in the stump to ensure non-slipping of the ligature. The stump is now pushed upwards into the abdomen, and one end of the ligature, which has been left long, passed through the inguinal (Poupart's) ligament, tied to the other extremity, and cut short. This helps to anchor the stump to the abdominal wall, and to keep it immediately above the aperture of the femoral (crural) ring.

(*c*) *Treatment of femoral* (*crural*) *ring and canal.*—The femoral ring is next closed by passing two or three sutures through that portion of the inguinal (Poupart's) ligament which lies in front of the ring, and then through the attachment of the pectineal fascia to the ilio-pectineal line (ligament of Astley Cooper), (Fig. 157). Each suture should be passed with a fully curved needle of moderate size, and ought to pick up the periosteum along the underlying portion of the ilio-pectineal line. Two or three sutures of this kind are usually enough. Care must be taken not to perforate the femoral vein, which lies immediately to the lateral side of the femoral (crural) ring. The femoral canal can be, in part, obliterated by dissecting up a flap of the pectineus muscle and its fascia,—the convexity of the flap being below, and the attached base above,—and fixing this to the inguinal (Poupart's) ligament by the insertion of a few interrupted silk sutures. This method, however, is not so satisfactory as that of fixing the arch of the inguinal (Poupart's) ligament to the periosteum of the ilio-pectineal line.

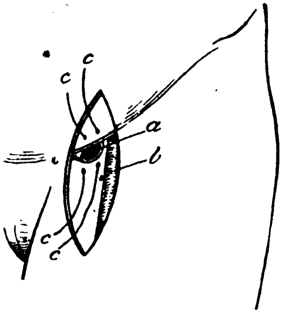

FIG. 157.—Femoral hernia. Method of fixation of the inguinal ligament to ilio-pectineal line.

a. Stump of hernial sac.
b. Femoral vein.
c. Sutures.

(*d*) *Closure of external wound.*—The margins of the aperture in the deep fascia are united by a continuous suture, and the skin wound is closed in the usual manner.

The transinguinal or "high" operation.—*Special instrument.*—Femoral hernia needle on handle.

Position.—As on page 192.

Operation.—A vertical incision is made over the swelling and extending upwards about one inch above the inguinal ligament. The skin and coverings of the sac are exposed, and the sac is carefully freed from the surrounding tissues, opened, and its contents reduced into the abdominal cavity. The edges of the skin incision are now retracted widely and the aponeurosis of the external oblique exposed. An incision is next made through the external oblique aponeurosis, starting ½ inch above and lateral to the pubic spine and extending for 2 inches parallel to the inguinal ligament (Poupart's), thus exposing the inguinal canal. The contents of the canal are retracted upwards and the posterior wall incised, bringing into view the neck of the hernial sac. It may assist in identifying the sac from above if its situation is marked by a blunt instrument passed through the femoral canal. The sac is now withdrawn through the femoral ring and delivered through the incised walls of the inguinal canal. It is again opened and examined, then its neck transfixed, ligatured as high up as possible with No. 1 silk, and the distal portion of the sac removed.

Treatment of the femoral ring.—The edges of the incision in the Falx aponeurotica inguinalis (conjoined tendon) are retracted and the ligament of Astley Cooper exposed. A suture of No. 3 silk on a femoral hernia needle is passed through the ligament of Cooper parallel to the ramus of the pubis and opposite the femoral ring. Each end of the silk suture is armed with a curved needle and passed through the inguinal ligament (Poupart's) from below—the ends of the suture emerging ⅓ inch apart and through the anterior wall of the femoral ring. The ends of the suture are left long and held by pressure forceps, to be tied at a later stage. Should the ring be very large a second or third suture will be necessary. The inguinal canal is restored by repairing its walls with interrupted sutures of No. 2 silk, and then the mattress suture described above is securely tied, obliterating the femoral canal by bringing the inguinal ligament (Poupart's) into contact with Astley Cooper's ligament. Care must be taken not to cause pressure on the femoral vein in closing the femoral canal in this way. The skin incision is closed with interrupted sutures of silkworm gut.

OPERATION FOR RADICAL CURE OF UMBILICAL HERNIA

Indications.—Many cases of umbilical hernia in adults, if other conditions allow, ought to be submitted to operation for the radical cure of the abnormal condition, since it is very difficult to keep up an umbilical hernia with a truss. Often, however, the patients are elderly females who suffer from bronchitis, and in these an operation, except in cases of emergency, is not desirable. The small umbilical hernia of children can usually be cured by the application of a suitable pad.

Position.—The patient is placed in the dorsal posture, the surgeon stands on the right side of the patient, and the assistant directly opposite to him.

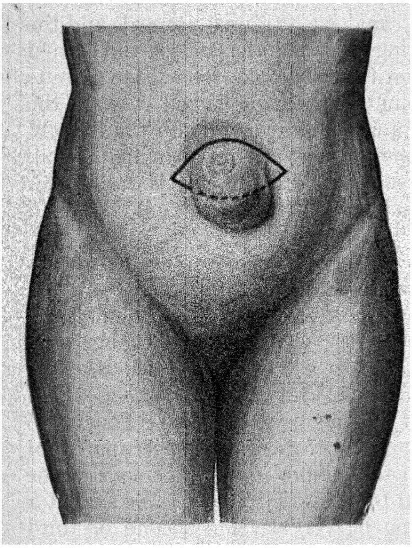

FIG. 158.—Umbilical hernia.—transverse incision.

Operation.—The stages of the operation are—

(*a*) *External incision, exposure, and opening of sac.*—An oval incision, either transverse or vertical in direction (Figs. 158 and 159), preferably the former, is made over the tumour (if this is large, over its lowest part), this is deepened until the sac has been opened. Care must be taken when making this incision, since it often happens that the wall of the hernial sac is very thin, and the contents of the sac may be easily injured owing to the presence of adhesions. The safest method is to pick up a small portion of the sac wall near the neck with dissecting forceps, and then divide it. It is not always easy to demonstrate the wall of the sac before opening it, but this should be done if possible.

(*b*) *Treatment and return of contents of sac.*—The sac having been opened for a distance of about 1 inch or more, according to the size of the hernial swelling, the contents are examined, and the constriction, if any, made out. This may be due to adhesions of the contents to one another, or to the wall of the sac, or be caused by an additional loop of intestine having been suddenly forced into the sac. When the seat of constriction has been made out it is divided, and a complete examination of the herniated structures made. If adhesions are present, they are separated; the contents of the hernial sac are then returned into the abdominal cavity. If the sac contains a large piece of omentum, it is usually advisable to unravel it, transfix it in several places, tie it in segments, and then remove the distal portion. The contents of the sac having been dealt with, the aperture in the aponeurosis is temporarily plugged with a flat gauze pad, which will prevent the further escape of intestines.

The sac is now dissected from its connections with the surrounding tissues until the neck is reached. If possible, the peritoneum which forms the sac should be separated from the margins of the aperture in the aponeurosis, and then sewn up with a continuous suture of chromicised catgut, the gauze pad being first removed. The portion of the sac beyond the line of suture is removed with scissors, and the stump pushed inwards towards the abdominal cavity.

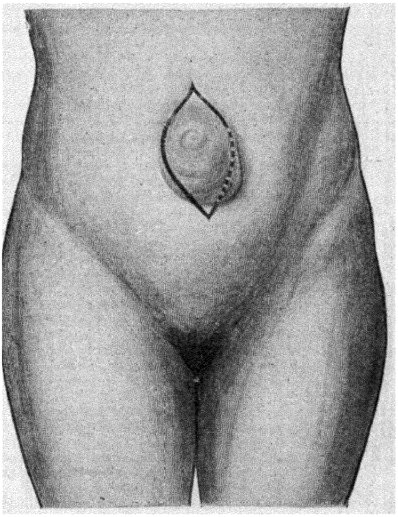

Fig. 159.—Umbilical hernia—vertical incision.

(*c*) *Closure of aperture in aponeurosis, and external incision.*—The margins of the aperture in the aponeurosis are pared away until the sheath of the rectus abdominis muscle on each side is opened. Next, the margins of the aperture are united together by the insertion of interrupted sutures. This may be done in one or more tiers. Usually the cut margins of the posterior layer of the sheath of the rectus are united to one another, then the margins of the two recti are approximated, and finally the anterior layers of the sheath. If possible, the layers should be made to overlap and sutured along two lines.

The margins of the incision in the skin and fasciæ are united in the usual manner.

OPERATIONS FOR STRANGULATED HERNIA

The most common herniæ are inguinal, femoral, and umbilical; obturator, sciatic, gluteal, and internal herniæ are rare. All varieties may become strangulated and require surgical intervention in order to save life. The operations for the relief of inguinal, femoral, umbilical, and obturator herniæ will be described.

Special instruments.—Needle on handle, hernia knife, hernia director.

Care must be taken not to injure the contents of the hernial sac by rough treatment during the preliminary preparation of the skin over the field of operation.

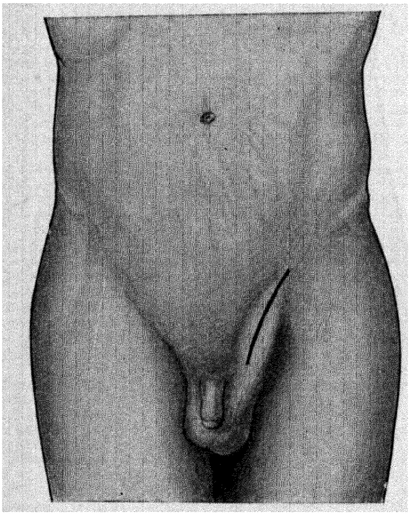

FIG. 160.—Inguinal hernia. Line of external incision in a case of strangulation.

Strangulated inguinal hernia. —*Position.*—The patient is placed in the dorsal posture, with the thighs slightly flexed, so as to relax the tissues in the region of the external abdominal ring. The surgeon stands on the affected side, and his assistant opposite to him.

Operation.—The operation itself may be described as consisting of the following stages, namely:—

(*a*) *External incision and exposure of the sac.*—An incision is made over the prominent portion of the hernial swelling, parallel to its long axis, and so situated that it extends a little distance (Fig. 160), above the subcutaneous inguinal (external abdominal) ring. This incision divides the skin and the fascial layers which cover the sac. It is not usually possible to recognise all the anatomical strata (Fig. 161), which form the coverings of a hernia, but often the intercolumnar fascia and the cremasteric layer can be distinguished. The wall of the sac can generally be recognised by its tenseness.

(*b*) *Opening of the sac, examination of its contents, and divison of the stricture which causes strangulation; treatment of the herniated viscus, and its return into the abdominal cavity.*—When all hæmorrhage from the superficial pudendal arteries has been arrested, a small piece of the sac wall is picked up with forceps and carefully divided with the scalpel. An escape of fluid indicates the opening of the sac. This fluid is generally blood-stained serum, but it may be purulent or consist of intestinal contents, though the latter condition is very uncommon. Often, however, this fluid contains septic micro-organisms, especially Bacillus coli, hence it is advisable to irrigate the interior of the sac with saline solution before dividing the constriction. A director is passed through the aperture made in the wall of the sac, and the opening is enlarged until the contents of the hernia are fully exposed. An examination of the intestine, omentum, or other viscus is now made, and its condition determined. If it is in a moderately healthy condition, such as will justify its return into the abdomen, the neck of the sac is freed and the situation of the stricture made out. The forefinger of the left hand, or a hernia director, is passed to the stricture, and when a director (Fig. 162) is used it is passed through it. The hernia knife (Fig. 163) is now passed along the finger or a director, and one or two small notches made into the tissue forming the constriction, upwards and laterally, until the opening is made large enough to allow the return of the herniated structure. This having been done, the director or finger is withdrawn, and in the

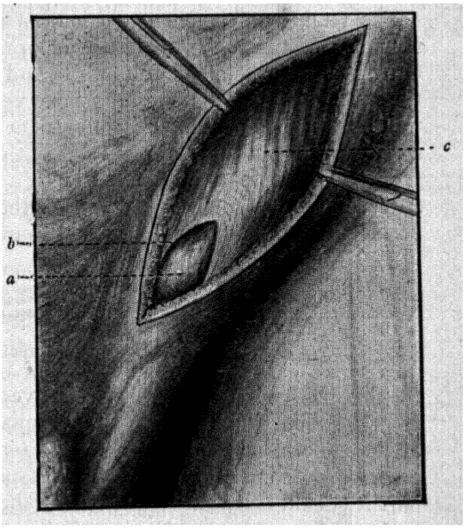

FIG. 161.—Inguinal hernia. Appearance of parts after division of skin of fascia and exposure of hernial swelling.

a. Hernial protrusion.
b. Subcutaneous inguinal ring.
c. External oblique.

case of intestine the loop is pulled downwards so as to allow the surgeon to make a visual examination of that portion of the gut wall which has been nipped in the stricture. If this is found to be non-gangrenous, the contents are gradually and gently manipulated back into the abdominal cavity. In the case of omentum, it is generally advisable to remove the herniated portion, after transfixing its base with a ligature, and tying it. If this piece is large, it should be drawn downwards, unravelled, and then transfixed in several places, tied in sections, and the distal portion removed.

The vitality of the herniated loop of intestine can be determined in most instances by testing it for the presence or absence of peristaltic movements in its walls, and by minutely observing the state of the circulation in the blood vessels. If the intestinal wall be pinched either with the fingers or dissecting forceps, and a wave of peristaltic movement follow the procedure, it may be safely assumed that the loop is not in a condition of gangrene. After division of the constriction at the neck of the sac, the herniated loop should be drawn downwards into the wound, and the line of constriction carefully investigated for ulceration or perforation. The colour of the herniated loop and the state of the endothelial covering of its peritoneal coat must also be carefully noted, and if any doubt exists as to the vitality of the part it should be washed with warm saline solution. If by this treatment the colour of the bowel changes from a deep purple, or even black, to a reddish colour, then there is no doubt that the vitality of the herniated loop is such that it can at once be returned into the abdominal cavity. When no changes are visible in the state of the circulation, the surface of the gut should be pricked with the point of a scalpel or a needle. This will show whether the circulation has been completely arrested or not. When the peritoneal coat of the bowel has lost its usual shiny appearance, and has rough greyish patches upon it, this indicates that the loop has lost its vitality, is in a state of gangrene, and ought not to be returned. The condition of the mesenteric veins in the prolapsed tissues should also be examined, and if they are found to be thrombosed it is strongly in favour of gangrene having been established, and hence in such cases the bowel ought not to be reduced.

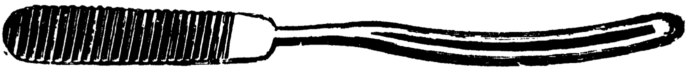

FIG. 162.—Hernia director.

When it has been determined that the loop of intestine within the hernial sac is in a condition of gangrene, the further treatment depends upon the general condition of the patient. If the patient is much collapsed, and not likely to survive a prolonged operation, the herniated loop of intestine should be anchored in the wound by the insertion of one or more sutures through its mesentery, and then the lumen opened so as to allow the contents to escape. If the constriction at the neck of the sac is so tight as not to allow the ready escape of intestinal contents, it should be notched sufficiently to permit a free outflow. Drainage is thus established, and dressings are applied. If the patient survive, resection of the remains of the gangrenous loop and end-to-end anastomosis are carried out at a later period, when the general condition has been much improved.

When the general condition of the patient is good, the gangrenous loop of intestine should be brought well into the wound, surrounded with warm towels and pads, and the dead portion removed by performing intestinal resection, after the method described on pp. 119 *et seq.* It is advisable to allow the intestinal contents to escape before completing the anastomosis. In those cases where only a small portion of a loop of intestine is gangrenous, and not more than a third of the circumference of the bowel involved, the gangrenous part should be inverted towards the lumen of the gut, and the sound surfaces of the intestine, proximal and distal to the gangrenous area joined together by the insertion of a series of silk sutures by Lembert's method. These sutures are arranged in a row at right angles to the long axis of the bowel.

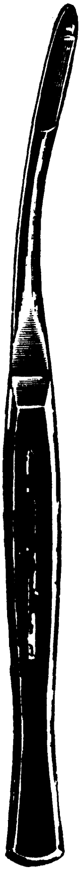
FIG. 163.—Operation for strangulated hernia. Hernia knife.

(*c*) *Closure of the hernial aperture and suturing of the external wound.*—These stages of the operation are similar to those described in connection with the radical cure of an inguinal hernia (pp. 188 *et seq.*).

Strangulated femoral hernia.—*Position.*—The patient is placed in the dorsal position, with the thigh of the affected side slightly flexed. The surgeon stands on the affected side, and his assistant directly opposite to him.

Operation.—The stages of the operation are similar to those described in connection with inguinal hernia (*q.v.*).

An incision about 2 inches long is made in the long axis of the hernial swelling, and is so situated that the upper extremity is a little below and ½ inch lateral to the pubic spine. This incision is in most cases on the inner aspect of the hernial swelling. The incision is deepened until the sac has been opened. In dividing the stricture the cut must be made upwards and inwards, so as to notch the free edge of the ligamentum lacunare (Gimbernat's), and to avoid the femoral vein, which is on the lateral side. In a small number of cases, 1 in 70, the obturator artery is given off from the inferior epigastric (deep epigastric), and runs in front of and then medial to the neck of the sac. When this abnormality occurs it may be divided, in which case the wound must be enlarged and a ligature applied to the cut extremity. The treatment of the hernial contents is similar to that mentioned in inguinal hernia, whilst the treatment of the sac and closure of the ring and wound are the same as in the radical cure of a femoral hernia (*q.v.*, p. 192).

Strangulated umbilical hernia.—When an umbilical hernia becomes strangulated, the sac must be opened by a vertical incision over it, or by a transversely oval incision which encloses the thinned skin in the region of the umbilicus, the sac then being opened laterally.

The contents are dealt with according to the methods described in the chapter on inguinal hernia, and this having been done a radical cure is performed as described on page 196. When the condition of the patient will not allow of resection of gangrenous bowel, the dead portion is opened and the loop fixed in the external wound, an artificial anus being established. If the patient recovers, this opening can be closed, or a portion of the bowel resected at a later period, and the hernial aperture closed as in the radical operation.

Strangulated obturator hernia.—In the treatment of a case of strangulated obturator hernia, an incision is made in the long axis of the swelling and on the medial side of the femoral vessels. This is deepened, the pectineus muscle and fasciæ being incised until the hernial sac is reached, which structure is opened in the usual manner. The stricture can be relieved by notching the obturator membrane at the inferior margin of the aperture. When the intestine is gangrenous, or when perforation has taken place, it is necessary to open the abdomen by an incision in the corresponding linea semilunaris, and to perform the requisite procedures from within the peritoneal cavity.

CHAPTER VI

OPERATIONS UPON THE LIVER AND BILIARY SYSTEM

1. Upon the Liver.

   Hepatotomy—(*a*) Abdominal, (*b*) Transthoracic, (*c*) Lumbar—
      (1) For hydatid cysts.
      (2) For abscess.
   Hepatectomy.
   Treatment of ruptures and wounds of the liver.
   For cirrhosis of the liver.

2. Upon the Biliary System.

   Cholecystotomy.
   Cholecystectomy.
   Cholecyst-enterostomy.
   Choledochotomy.

Operations upon the Liver

Hepatotomy.—By the term "hepatotomy" is understood making an incision into the liver. This operation is indicated in the following conditions:—

(*a*) In cases of hepatic suppuration.

(*b*) In cases of cystic disease of the liver, especially in hydatid disease.

The liver may be approached either through the abdominal or thoracic walls. The abdominal operation will be first described.

Position.—The patient is placed in the dorsal position, or lying somewhat on the sound side, if it is proposed to make an incision on the lateral aspect of the trunk. A hard sandbag or pillow should be placed underneath the lower dorsal region of the spine, so as to lift forward the liver and thus make the organ rise nearer the parietal wound. The surgeon stands usually on the right side of the patient, and his assistant on the left.

Special instruments.—Exploring syringe or aspirator, needles (large fully curved), cautery.

The abdominal operation.—The operation of hepatotomy may be divided into four stages, namely:—

(*a*) *Parietal incision.*—An incision about 3 inches in length is made over that portion of the liver which is supposed to be the seat of the abscess. It may be necessary to puncture with an exploring needle or the needle of an aspirator before this can be determined. The incision usually commences at the costal margin, and extends downwards. This incision is deepened until the peritoneal cavity has been opened. If the inflammation has caused obliteration of that part of the cavity which lies between the affected part of the gland and the abdominal wall, the general peritoneal cavity is not opened, but this condition is of rare occurrence in cases of hepatic suppuration.

(*b*) *Exposure of liver, incision of wall of abscess, and evacuation of pus.*—The liver lies exposed in the bottom of the wound after the peritoneum has been divided, and the margins of the parietal incision held aside. The adjacent portion of the peritoneal cavity is packed off with flat gauze sponges, so as to avoid septic contamination of the peritoneum and adjacent viscera when the abscess is opened.

The situation of the pus can usually be determined, either by the presence of a swelling on the surface of the liver, or by the presence of fluctuation. If there is any uncertainty as to the position of the asbcess, the exploring syringe should be used.

The situation of the hepatic abscess having been determined, an incision about 1½ inches in length, and parallel to the external wound, is made in the hepatic substance over the abscess. When the abscess has been reached, all hæmorrhage is arrested from any hepatic vessels which may require ligature, the opening is then dilated with the finger or a pair of dressing forceps, and the pus allowed to escape. As the pus is escaping, the assistant should be directed to press the anterior abdominal walls against the liver, so as to prevent pus passing into the peritoneum. In some cases it will be found convenient to pass the forefinger into the cavity of the abscess, and to hook the gland forwards. When the pus has been evacuated, the interior of the abscess cavity is examined with the finger so as to determine whether any other abscesses are present. If any are found the intervening tissue is broken down with the finger, and the contents allowed to escape. The interior of the cavity is next irrigated with saline solution, and the aperture temporarily plugged with a sponge or strip of gauze.

(*c*) *Union of margins of hepatic incision to those of parietal wound.*—All sponges and pads are removed from the peritoneal cavity, and the peritoneum in the region of the hepatic incision is well sponged or locally irrigated if much contamination has taken place.

Next, the margins of the incision in the liver are united to those of the incision in the abdominal wall, by the insertion of a ring of interrupted sutures of chromicised catgut. Each suture is entered at the deep part of the incision in the liver, and traverses the hepatic substance until it emerges about ½ inch from the margin, it is then passed through the parietal peritoneum and the fascial and muscular or aponeurotic tissues of the abdominal wall. The sutures are introduced at intervals of about one-quarter of an inch.

Just beyond the upper and lower extremities of the hepatic incision a suture should be passed through the abdominal wall, then through the liver substance beyond the angle of the wound, and finally through the abdominal wall on the other side of the incision. When all these sutures have been inserted they are tied and the ends cut short, the two sutures at the extremities being tied last. That portion of the wound in the parietes to which the margins of the hepatic incision are not attached is closed in the usual manner.

(*d*) *Establishment of drainage.*—When the cavity of the abscess is not very large the interior should be packed with a long strip of absorbent gauze, one end of which protrudes from the external wound. This should be removed daily, and replaced by a similar strip. Some prefer to insert a drainage tube, one end of which passes out from the external wound. An objection to the employment of this, at least immediately after the operation, is that it allows venous oozing to take place from the walls of the abscess. Another objection is, if the tube is too long or too stiff, that the lower extremity may lacerate the walls of the abscess cavity during the movements of respiration; again, the aid of capillary attraction is wanting in the case of a drainage tube.

Hepatotomy for hydatid cyst of the liver.—This operation does not differ essentially from that for "abscess."

When the abdomen has been opened and the cyst exposed, the peritoneum in the neighbourhood is packed off with flat sponges and the cyst wall incised. The contents are evacuated, and the margin of the cyst wall stitched to those of the parietal incision, and drainage established. Before suturing to the abdominal wall, an attempt should be made to remove the endocyst. This can often be pulled out by seizing a portion of the cut margin, exerting traction, and assisting the separation by sponge pressure. In these cases, as a rule, no septic complications are present.

Some surgeons have advised that after the cyst wall has been incised, and the contents evacuated, the cyst should be dropped back into the peritoneal cavity and the abdominal incision closed. The aperture in the cyst wall may or may not be closed. This method of treatment has not as yet become well established and in my opinion is not advisable. There are several objections to its adoption, such as the subsequent deposit of calcareous matter in the wall of the cyst, and the possibility of infection of the peritoneum with the parasite.

Others again have dissected out the cyst and then sutured the walls of the resulting cavity in the liver together, with numerous points of suture. The results of these operations, however, have not justified their general adoption. The best results will be obtained by incision, evacuation of contents, removal of endocyst, suture of margins of incision in cyst to parietal wound, and drainage.

Excision of ribs to expose the convex or right lateral surface of the liver by a transthoracic operation.—*Indications.*—This operation is requisite in the following clinical conditions:—

(*a*) Subphrenic hydatid cyst which is not readily accessible through an abdominal incision.

(*b*) Subphrenic abscess which is not accessible through an abdominal incision.

(*c*) Abscess of the superior part of the liver which extends upwards towards the thorax.

Position.—The patient is placed lying somewhat on the left side, so as fully to expose the lateral aspect of the right side of the chest. The surgeon stands on the right side of the patient, and the assistant on the opposite side.

Special instruments.—Periosteal elevator, small saw, bone forceps or rib shears.

Operation.—A site is selected on that part of the thorax which overlies the most prominent portion of the swelling, and an incision 3 to 4 inches long, which may be lengthened if necessary during the later stages of the operation, is made parallel to the ribs. A rib is exposed, usually the ninth, in the mid-axillary line, the structures attached to it separated, and then a portion of it is excised (see p. 658). The underlying costal layer of the pleura is next divided, and the pleural cavity opened, whereupon the air rushes inwards, and the lung on the corresponding side becomes collapsed. The layer of pleura which covers the subjacent portion of the diaphragm is now sought for and brought as far as possible into the wound, and an incision an inch or more in length is made in it. The margins of the incisions in the two layers of pleura (costal and diaphragmatic) are closely approximated and united by numerous fine sutures of chromicised catgut. In this stage of the operation it may in some cases be found necessary to aspirate the hepatic swelling and remove a portion of its fluid contents, so as to relax the diaphragm and the overlying pleura.

The diaphragm in the bottom of the wound is now incised, and sutures are passed through it so as to fix it to the margins of the wound in the thoracic wall. By this means the pleural cavity of the affected (right) side is completely shut off from communication with the external atmosphere, and also from the swelling which is about to be incised.

If the incision in the thoracic wall is in the lower part, and the lung can be pushed upwards, the costal and diaphragmatic layer of the pleura may be sutured together before incision, in which case collapse of the lung is obviated, or occasionally it may be possible to strip upwards the pleural sac from below.

Often it will be found that the two layers of pleura are adherent as the result of inflammation, in which case the pleural sac is not opened, the incision being made through the adherent area. In all cases the aim of the surgeon should be to avoid causing entire collapse of the lung, but this often cannot be done.

Hepatotomy through a lumbar incision.—In this form of operation an incision is made in the lumbar region of the right side, parallel with the lower margin of the last rib, and the various fascial and muscular strata cut through until the lower margin of the posterior aspect of the liver is exposed. This is then incised and treated as has been already described in the abdominal and transthoracic operations. The selection of this route of attack by the surgeon in cases of hydatid cyst or abscess of the liver or subphrenic region is not often possible, since these affections only rarely present in the lumbar region. Occasionally, however, they do so, and then the lumbar operation should be selected, since the cyst or abscess can be opened without incising the peritoneum, and very good drainage established.

An incision is now made through the hepatic or other tissue which is exposed at the bottom of the wound, and this is deepened until the cavity of the abscess or hydatid cyst is reached.

The contents are evacuated, and the cavity is treated in a manner similar to that described when the abdominal operation was under consideration.

The extremities of the incision in the abdominal wall may be closed with sutures if it is thought advisable, and drainage established by a tube and gauze packing.

Hepatectomy.—It is only during recent years that surgeons have successfully removed portions of the liver by operation. The operation has been called " resection of the liver," or hepatectomy. In those cases in which portions of the liver have been removed a fair amount of success has been met with, and it is to be hoped, by the introduction of improved details of technique, that this operation may become a recognised and justifiable one, since there are many affections of the liver which only admit of a cure being obtained by a complete and radical removal of the diseased tissue. All operations of this nature which involve the liver are limited to the removal of a portion of the organ, since it is not possible for a person to live when the entire gland has been taken away, even if this operation were possible merely from an operative point of view. The removal of portions of the liver can be effected according to one of the following methods.

Indications.—(*a*) Carcinoma of the gall-bladder, infiltrating the adjacent portion of the liver, and not associated with secondary growths elsewhere beyond affection of the lymph glands in the hepato-gastric ligament.

(*b*) Localised malignant tumours of the liver (sarcoma and carcinoma), when not associated with other visceral growths.

(*c*) Some cases of localised cystic disease of the liver.

(*d*) Some cases of calcareous gummata of the liver.

(*e*) Some cases of angiomatous tumours of the liver, which have become thrombosed and calcareous.

Special instruments.—As for hepatotomy, and in addition a long elastic ligature and compressor for the portal vessels.

Position.—The patient is placed in the dorsal position, with a firm sandbag underneath the lumbar and lower dorsal regions of the spinal column. The surgeon stands on the right side of the patient, and the assistant directly opposite to him.

Operation.—(*a*) *Excision of a portion of the liver by the employment of a " wedge-shaped " incision.*

An incision from 4 to 6 inches in length is made through that portion of the abdominal wall which overlies the affected portion of the liver, commencing above at the costal margin and extending downwards in a vertical direction. Usually the operation is performed on account of a carcinomatous growth of the gall-bladder extending into the adjacent part of the liver, in which case the incision will commence at the costal margin opposite the eighth or ninth costal cartilage and extend downwards, the rectus abdominis muscle when exposed either being retracted inwards or its fibres vertically separated. This incision is deepened until the parietal peritoneum is reached, when it is divided for the entire extent of the wound. The nerves of the abdominal wall should be preserved as far as possible by retracting them upwards and downwards when they are exposed in the outer and posterior part of the rectus sheath. All hæmorrhage from blood vessels in the incised abdominal walls is arrested by ligature of the vessels, and then that portion of the liver which it is wished to remove is brought well into the wound and made if possible to protrude externally, and the adjacent viscera and peritoneum protected by covering with large gauze pads.

At this stage the hepato-gastric ligament (small omentum), the lymph glands lying upon the anterior aspect of the underlying portion of the spinal column, and the other parts of the liver should be carefully examined so as to ascertain in cases of malignant disease whether there are any secondary growths present. Under these circumstances resection of the primary growth and a portion of the liver would be contra-indicated.

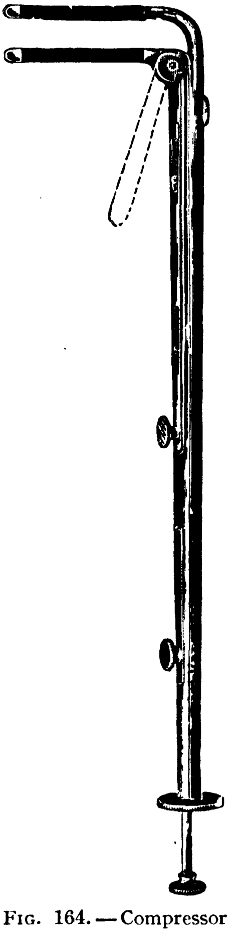

FIG. 164. — Compressor for hepatic artery and portal vein.

The diseased area being thus defined and the position of the incisions in the hepatic tissues determined, if possible an elastic ligature is made to encircle that portion of the liver in which the diseased area is located, and tightened sufficiently to control hæmorrhage. Often, however this is not possible owing to the position of the diseased tissues in which case an assistant should grasp the liver on each side of the growth, or if this cannot be done the circulation must be controlled by compression of the hepatic artery and portal vein either digitally—in which case an assistant passes his hand into the abdominal cavity in such a manner that the forefinger is in the epiploic foramen (foramen of Winslow) and the thumb on the anterior aspect of the hepato gastric ligament (small omentum) —or by the use of the " hepatic compressor " shown in Fig. 164.

Incisions are next made through the hepatic tissues in the " wedge-shaped " manner shown in Fig. 165, and the diseased area removed. As each incision is made an assistant covers the exposed surface with a large flat gauze pad. The cut surfaces are then uncovered, a small area at a time—and all cut arteries and veins picked up with forceps and ligatured with fine silk. Occasionally a cut vessel is most easily ligatured by passing a small curved needle armed with fine silk around it. If the vessels are not readily visible the assistant controlling the circulation should be directed to relax his pressure, when the divided blood vessels will at once become apparent.

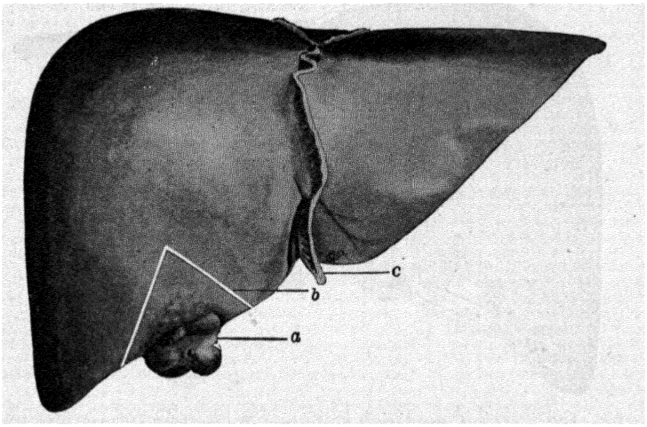

FIG. 165.—Resection of liver (for carcinoma of gall-bladder). Position of incision.

a. Gall-bladder, seat of carcinoma involving adjacent part of liver.
b. Line of incisions.
c. Suspensory ligament.

The piece of liver and the contained tumour, when removed in this manner, have the form and shape of a blunt wedge, and the wound, which is left after the removal of the diseased portion, presents two surfaces which can easily be brought into apposition in a manner similar to that in which the two flaps of an amputation wound are approximated.

The bleeding points having been arrested, a large curved needle, with a rather blunt point, is taken armed with a No. 3 chromicised catgut suture, and passed through the margins of the wound in the liver according to the method depicted in Fig. 166, a row of sutures being introduced, the distance between two individual sutures being about one-third or one-quarter of an inch. All the sutures should be put in before any are tied. The entire row having been inserted, they are tied and the ends cut short, care being taken when tying them that each suture is only tied tight enough to hold the surfaces of the liver in approximation. If much force is used, the sutures cut out and cause the approximated margins to be irregular and lacerated. The stump of liver is now allowed to fall back into the abdominal cavity, sponges and pads are removed, and the exposed area of peritoneum sponged dry.

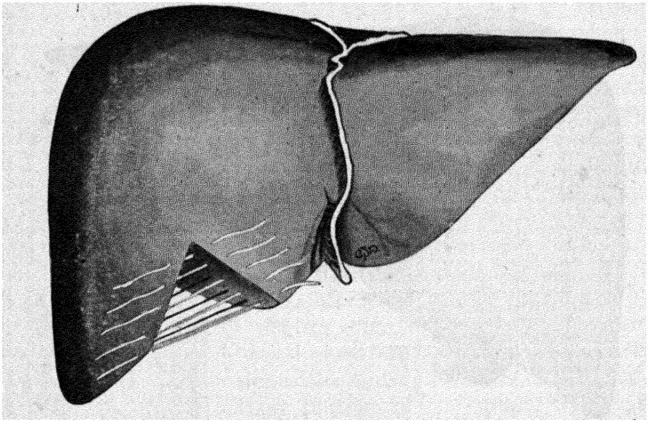

FIG. 166.—Resection of liver. Method of inserting sutures into the liver after a "wedge-shaped" portion has been removed. This diagram shows all the sutures in position before any have been tied. In this case the portion of the gland which has been resected has been from the antero-inferior margin, and the adjacent parts of the inferior and anterior surfaces of the right lobe.

If there is much oozing from the area of operation, it should be packed with a long wide strip of gauze, one end of which is brought out through a portion of the parietal wound left open for the purpose. Otherwise the margins of the parietal wound are closed by the insertion of three tiers of sutures in the manner already described.

(*b*) *Removal of tumours and cysts from the liver by dissection, and subsequent closure of the wound in the liver by sutures, together with simultaneous closure of the abdominal incision.*—Tumours of the liver which are completely encapsuled, or hydatid and other forms of cysts which are embedded in the gland, may be removed by dissection. After the surface of that portion of the liver which contains the tumour or cyst has been exposed by an incision in the abdominal wall, the surrounding portion of the peritoneal cavity is packed with sponges, so as to avoid contamination of the peritoneum with blood or foreign material, or injury to the intestines, and then an incision is made into the hepatic substance, until the superficial portion of the tumour is exposed. The tumour or cyst is then separated from the normal hepatic tissue by a process of careful dissection.

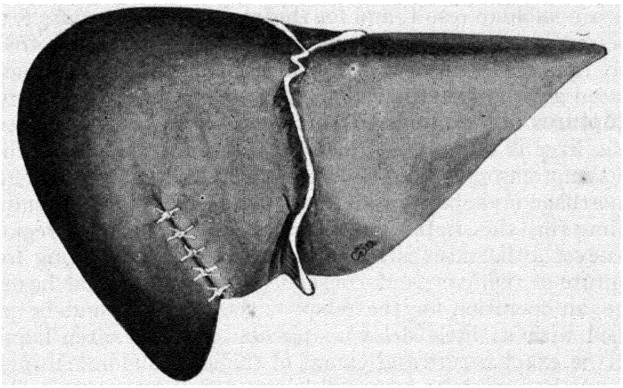

FIG. 167.—Resection of liver. Same as Fig. 166, but with all the sutures tied and the ends cut short.

The circulation in the liver can be controlled during operations upon it by an assistant passing the forefinger into the epiploic foramen (foramen of Winslow), and placing the thumb on the anterior aspect of the hepato-gastric ligament (small omentum), and then exerting pressure. A more convenient method of compressing the hepatic artery and the portal vein is by use of the instrument depicted in Fig. 164, or by a pair of pressure forceps, the blades of which have been covered with thin rubber tubing.

The surfaces of the wound left by the removal of the cyst or tumour are approximated and fixed in apposition by the insertion of a number of interrupted deep sutures of No. 2 or 3 chromicised catgut. The external wound is closed in the usual manner.

Other methods of removing tumours of the liver have been practised, but they are not so satisfactory and do not give such good results as the two above described.

These methods are—(*a*) Fixation of the diseased portion of the liver in an abdominal wound, and application of an elastic ligature to its base, so as to cause sloughing of the parts distal to the ligature; or (*b*) fixation as above, and removal of the affected part after the liver has become adherent to the margins of the incision (*opération à deux temps*). Owing to the sloughing which takes place in the first method, septic complications are liable to result, and for this reason the procedure is not to be recommended; and as regards the second method, this is rarely applicable, owing to the difficulty of bringing the entire diseased area outside the abdomen.

Ruptures and wounds of the liver.—*Indications.*—Rupture of the liver is occasionally met with as the result of violence. The symptoms presented by the patient are those of internal hæmorrhage and shock, and often the presence of a fluctuating swelling in the right lumbar and hypochondriac regions. Whenever a diagnosis is made that a patient is suffering from a rupture of the liver, and consequent intra-peritoneal hæmorrhage, an operation for the relief of the injury should be performed with as little delay as possible. It will often happen that the exact nature and extent of the intra-abdominal injury will only be established when the abdomen has been opened.

Operation.—The peritoneal cavity should be opened above the umbilicus by an incision 3 to 4 inches long, either in the right linea semilunaris or a little to the right of the linea alba. The former incision should be adopted in those cases in which the physical signs definitely locate the injury in the right hypochondriac region. When the peritoneal cavity has been opened, all blood, blood-clot, or bile should be quickly sponged away and the margins of the abdominal wound widely retracted, so as to expose as much as possible of the surface of the liver. If the injury is not then visible, the hand should be introduced into the peritoneal cavity, and passed upwards to the right and to the left, so as to palpate the surfaces of the liver, and thus detect any solutions of continuity upon its surface and into its substance. When these have been detected, the margins of the parietal wound should be held widely apart, and the injured part of the viscus lifted up towards the surface, the surrounding viscera being protected from injury and contamination by flat gauze sponges or pads. The margins of the rents should first be sponged dry, and any torn and bleeding blood vessels picked up with pressure forceps and ligatured. Next, the margins of the rupture are brought into apposition, and fixed by the insertion of a series of interrupted suture of chromicised catgut. Each suture is inserted with a curved, round-bodied needle, entering ⅓ inch from the margin of the tear, extending through the liver substance beyond the bottom of the rupture, and having its exit a similar distance beyond the opposite margin. The sutures should be ¼ inch apart, and all should be introduced before any are tied. When all the sutures have been inserted they are tied in such a manner that the margins of the rupture are brought into complete and moderately firm apposition, whilst the hepatic substance is not torn by the sutures themselves. When the repair of the injuries has been completed, the surface of the injured portion of the liver and the adjacent peritoneum are carefully sponged so as to remove all traces of blood and bile, and then the flat sponges or pads are removed. When there is much hæmorrhage at the time of operation, it can be controlled until the bleeding vessels are secured, by grasping the structures in the gastro-hepatic ligament (small omentum) between the finger and thumb, or applying the hepatic compressor illustrated in Fig. 164. The wound in the parietes is finally closed in the usual manner, but if oozing of blood continue, owing to extensive laceration, the bleeding area should be packed with a long strip of gauze, one end of which is brought out through an angle of the parietal wound left unsutured for the purpose.

If the injury to the liver is extensive, it may be necessary to enlarge the original incision in an ⅂-shaped manner, so as to enable the operator to obtain a good exposure of the damaged parts.

Perforating wounds of the liver, such as stabs and gunshot wounds, which necessitate operative interference, are usually most conveniently treated by enlarging the external wound until the injured portion of the viscus is laid bare, and then treating it by the method above described.

Porto-parietal venous anastomosis.—*Omentopexy-epiplopexy.*—This operation consists in fixation of the large omentum to some portion of the anterior abdominal wall so that it may become adherent, and new anastomoses and communications may form between the veins in the great omentum—branches of the portal vein—and veins of the anterior abdominal wall—tributaries of the general systemic venous system. At the same time, the convex surface of the liver and the adjacent portions of the parietal peritoneum are rubbed with gauze so as to remove as much as possible of the endothelial layers ; or scarified with the point of a knife, or scraped with a sharp spoon. These procedures have for their object, inducement of adhesions between the surface of the liver and the adjacent portion of the abdominal wall.

Indications.—The clinical conditions which indicate the performance of this operation are :—

(*a*) Cirrhosis of the liver, either of the atrophic or cardiac variety, which has caused ascites.

(*b*) Chronic perihepatitis causing obstruction to the portal vein or its branches.

(*c*) Obstruction of the portal vein, due to thrombosis.

Position.—The patient is placed in the dorsal position, the surgeon stands on the right side of the patient and his assistant directly opposite.

Operation.—A vertical incision, 3 inches long, is made in the middle line of the abdomen, commencing a little below the xiphoid process (ensiform cartilage) and terminating at the umbilicus. The different strata are incised and the peritoneal cavity opened. All fluid is removed from the peritoneal cavity by sponging, or syphonage with a large rubber tube which is passed downwards to the bottom of the pelvis. The convex surface of the liver in the region of the upper portion of the incision and the adjacent portions of the parietal peritoneum are well rubbed with a piece of gauze or scraped with a sharp spoon so as to remove as much of the endothelial layers as possible. A strip of gauze or a gauze pad is then temporarily placed over and between the rubbed surfaces, so that any blood which may exude is absorbed. Next, the scar tissue of the umbilicus is excised, and the posterior aspect of the rectus abdominis muscle on each side exposed by opening and separating the sheath. The great omentum is now brought into the wound and its lower part placed in the rectus sheath on each side, and fixed there by the insertion of a few points of chromicised catgut sutures. It is also fixed in a similar manner to the margins of the opening in the peritoneum. The exposed parts are sponged dry, and the gauze packing removed from the region of the liver. The margins of the muscular aponeurosis are then joined together by interrupted sutures of silk, and those of the skin and fascial layers by sutures of silk-worm gut.

Other methods of performing this operation are—suture and fixation of the omentum between the parietal peritoneum and the overlying fascial layer, or between the superficial surface of the aponeurosis and the skin. The method recommended has in my experience given the best results. This is probably explained by the fact that the veins of the great omentum are fixed to and form anastomoses with the large veins of the anterior abdominal wall—the inferior deep and superior epigastric veins which are tributaries of the external iliac and internal mammary veins respectively.

Operations upon the Biliary System

Cholecystotomy.—Cholecystotomy implies making an incision through the wall of the gall-bladder. The gall-bladder is attached to the inferior surface of the liver, and lies in a wide groove just to the right of the quadrate lobe; the fundus of the sac lies immediately behind the tip of the costal cartilage of the right ninth rib, and at this point often projects slightly beyond the inferior margin of the liver, especially when it is distended.

Indications.—The operation is performed for the following conditions, namely—

(*a*) Gall-stones within the gall-bladder.

(*b*) Collections of pus or fluid in the gall-bladder, which are due to impaction of gall-stones, or to inflammatory conditions of the mucous membrane of the gall-bladder dependent upon septic micro-organisms.

(*c*) The removal of gall-stones impacted in the proximal portion of the cystic duct.

(*d*) Certain cases of pancreatitis in which it is desired to drain the gall-bladder.

Special instruments.—Cholecystotomy forceps and scoop, needles (fully curved and half curved), aspirating needle, trocar and cannula, self-retaining retractor.

Position.—The patient is placed in the dorsal position, and near the right side of the table. The surgeon stands on the right side of the patient, the chief assistant directly opposite to him

Operation.—The operation may be divided into the following stages, namely—(*a*) *Parietal incision.*—An incision from 3 to 3½ inches long is made through the anterior abdominal parietes commencing above at the tip of the ninth right costal cartilage and extending downwards towards the right pubic spine (Fig. 168). The incision is deepened until the peritoneal cavity has been opened, care being taken to avoid notching the liver or injuring the intestines. When the rectus muscle has been exposed, its fibres are separated in a vertical direction, as few fibres as possible being divided with the scalpel. The incision should be so situated that it lies over the right rectus abdominis muscle, about half an inch to three-quarters of an inch from its external margin. When more room is required the incision can be prolonged obliquely upwards and inwards towards the ensiform cartilage.

(*b*) *Finding of gall-bladder and bringing it into external wound.*—If the gall-bladder does not at once protrude, the margins of the incision are held apart with retractors, and the fingers of the right hand are introduced into the peritoneal cavity, and the viscus is sought for on the lower aspect of the liver. In many cases it will be found to be enlarged, and often attached to the adjacent structures by strong adhesions. When the situation of the organ has been made out it is brought into the wound, and any adhesions which prevent this being done are divided if requisite.

(*c*) *Incision of gall-bladder, and removal of calculi and other pathological collections from interior.*—If the gall-bladder is very large, owing to distension with fluid, part of the fluid contents may be evacuated by aspiration with an aspirator. The margins of the perforation with the aspirator needle are seized with forceps, and an incision about ½ inch in length made through the wall of the gall-bladder on the convexity of the fundus, and passing through the seat of perforation, if one has been made. Before making this incision, the surrounding portion of the peritoneal cavity is packed with flat gauze sponges, so as to prevent contamination as far as possible. The interior of the viscus is next examined with the finger, and the size, shape, and locality of any gall-stones which may be present made out. These bodies are then removed, either with cholecystotomy forceps or a scoop, whichever may be the more convenient. When the gall-bladder has been emptied the cystic duct is examined from the interior of the viscus, and if any calculi are present they are removed. The interior of the organ is washed out by irrigation, and a small sponge or gauze tampon placed in the aperture, which will serve as a temporary plug, and prevent the escape of fluid into the peritoneum. The sponges which have been placed around the organ in the peritoneal cavity are removed, and the course of the hepatic

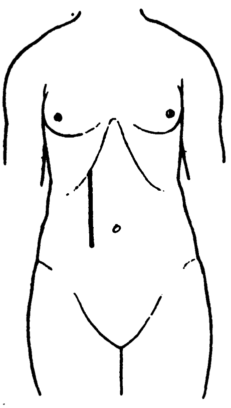

FIG. 168.—Cholecystotomy. Position of parietal incision.

and bile ducts examined with the finger. If these do not contain calculi, and are otherwise normal, the region of the gall-bladder is thoroughly cleansed by sponging, and the margins of the incision in the fundus attached to those of the parietal wound.

(*d*) *Fixation of margins of wound in gall-bladder to those of parietal incision, and closure of the remainder of the external wound.*—The margins of the gall-bladder incision are brought into apposition with those of the upper portion of the parietal wound, and fixed there by the insertion of sutures. The sutures are best introduced in the following manner. On each side of the incision in the gall-bladder a row of sutures are inserted, one-sixth of an inch apart, each suture passing through the posterior layer of the rectus sheath, and the fascial and serous strata of the abdominal wall, and then through the wall of the gall-bladder into its interior. At the

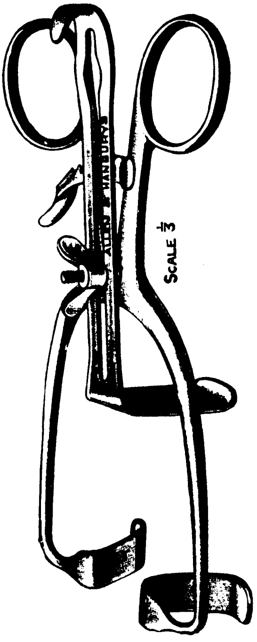

FIG. 169.—Self-retaining retractor with three blades.

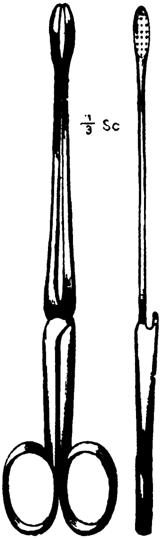

FIG. 170.—Cholecystotomy forceps.

upper and lower extremities a suture is passed from one side of the parietal incision to the other, taking up the gall-bladder just beyond the incision by passing through its muscular and serous coats. The portions of the parietal wound above and below the sutured part of the gall-bladder are closed by sutures in the usual fashion. All the sutures are introduced before any are tied. When all the sutures have been inserted they are tied, the sponge plug removed from the interior of the gall-bladder, and

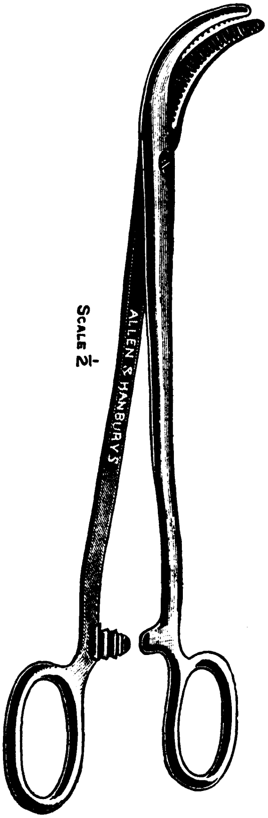

FIG. 171.—Gall-bladder forceps.

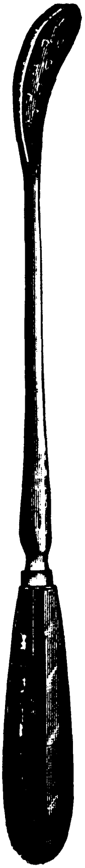

FIG. 172.—Cholecystotomy scoop.

a rubber tube passed down into the cavity of the viscus, so as to act as a drain. If silk be used for the sutures, each suture should be cut with long ends, so that they can be readily removed when union has taken place. If they are cut short and the gall-bladder is septic, considerable trouble may result and a fistula be formed. Chromicised catgut No. 2 will usually be found to be the best suture material for this operation.

Instead of fixing the gall-bladder in the manner above described; in some cases it is best treated as follows:—

A No. 12 English red rubber catheter is passed into the gall-bladder, its lip remaining at least one inch distal to the neck of the viscus. The opening in the gall-bladder is closed around the catheter with a purse-string suture of No. 1 catgut, one stitch of which is used to anchor the catheter. A second purse-string suture is passed about one-sixth of an inch distal to the first and tied with the catheter pushed forwards into the bladder. The first purse-string suture is thus buried, and an "inverted cone" is produced. If the fundus of the gall-bladder is sufficiently large, a third purse-string may be inserted.

(In most cases it is unnecessary to fix the gall-bladder to the anterior wall. The organ may be allowed to drop back into the wound and the parietes closed around the catheter.)

A stab wound is made through the abdominal wound about two inches to the right of the original incision and over the fundus of the gall-bladder. A forceps is passed through the wound from the outside, and the distal end of the catheter seized and drawn back through the wound, care being taken to avoid tension on the gall-bladder. The catheter should not be fixed to the skin by a suture as leakage of bile is liable to occur along the stitch. The original incision in the abdominal wall may now be closed in layers without drainage.

The above operation is the ordinary one adopted in the removal of gall-stones from the interior of the gall-bladder and the cystic duct. It will be seen, however, that a fistula is established, through which the bile from the gall-bladder drains for a time. In favourable cases this fistula closes within three to five weeks. On account of the formation of a fistula, it is more correct to call the operation "cholecystostomy."

Cholecystendysis.—In favourable cases, where the walls of the gall-bladder are in a perfectly healthy condition and at the same time are thick and muscular, it is possible to close the incision in the gall-bladder at the time of operation, to drop the viscus back into the peritoneal cavity and then to close up the external wound. When this is done, two tiers of sutures should be inserted, the first transfixing the entire thickness of the gall-bladder a little external to the margins of the incision, and the second the serous and muscular coats. This form of operation is called " cholecystendysis," or " ideal cholecystotomy."

The cases which are suitable for this form of operation—that is, gall-bladder with sound healthy walls, free from inflammation and ulceration, and containing one or more small or medium-sized calculi—are not frequently met with. The danger of the operation is leakage of the contents of the gall-bladder into the peritoneum, and consequent peritonitis. On this account the operation is not recommended.

Cholecystectomy.—Removal of the gall-bladder is known as cholecystectomy.—The operation has been performed for the following conditions :—

(*a*) Localised and primary malignant growths of the gall-bladder.

(*b*) Rupture and perforation, when the region of the neck of the gall-bladder has been involved, or the injury has been extensive.

(*c*) In cases of mucous fistula associated with obliteration of the lumen of the cystic duct.

(*d*) Many cases in which the gall-bladder has long been distended with gall-stones and retained secretions, its walls thinned and in places ulcerated.

(*e*) Cases of gall-stones in the gall-bladder in which the gall-bladder is contracted with thickened walls, or ulcerated, or in which there is constriction of the viscus following old ulceration.

(*f*) Cases of gall-stones in which the cystic duct is ulcerated or the seat of a stricture.

(*g*) Gangrene of the gall-bladder.

(*h*) In cases of membranous or phlegmonous cholecystitis.

Choice of operation—Cholecystotomy or Cholecystectomy.—Generally it will be found that the condition of either the gall-bladder or the cystic duct, or both, is such that cholecystectomy is indicated. The loss of the gall-bladder does not appear to occasion any bad results, and as the origin of the formation of gall-stones is undoubtedly to be found within the gall-bladder itself, it appears to me that usually excision of the organ is the better operation. The risks of the operation in properly selected cases are not greater than in cholecystotomy, whilst the likelihood of recurrence of gall-stones is almost nil, and the period of convalescence is much shorter, since the wound can be sewn up.

In the latter class of case the period of rest in bed is shortened, there is no annoying biliary fistula for a time, and the risk of further formation of gall-stones is minimised. The risks of the operation do not appear to be greater than when a fistula is established.

Operation.—The instruments and the early stages of the operation are similar to those employed in cholecystotomy. When the peritoneal cavity has been opened and the liver rotated upwards so as fully to expose the lower aspect, the gall-bladder is separated from the inferior aspect of the liver by dividing the peritoneum on each side of the groove in which it lies, as well as around its fundus in the region of the anterior inferior border. When this has been done, the organ is separated from the liver with the fingers, all bleeding vessels which are met with being tied as the operation proceeds. By this means the gall-bladder is separated from the liver until the cystic duct is reached. With a needle on a handle, or a medium-sized curved

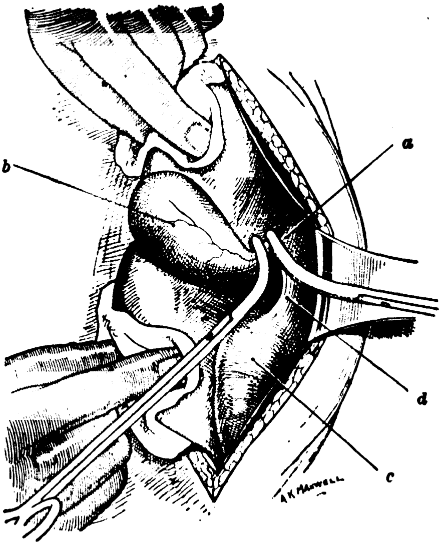

FIG. 173.—Cholecystectomy. Method of separation of gall-bladder commencing at cystic duct. A pair of pressure forceps has been placed on cystic duct a short distance from where it joins the bile duct.

a. Cystic duct.
b. Gall-bladder.
c. Duodenum.
d. Free margin of gastro-hepatic omentum.

needle held by a needle-holder, a moderately stout ligature of chromicised catgut or silk No. 2 is passed around the cystic duct and tied. The duct is then cut across, and the gall-bladder removed. Another method of removal of the gall-bladder, after it has been fully exposed, is to commence from above. The position of the cystic duct is defined and the peritoneum divided around it and pushed back towards the bile duct. Two pairs of long curved pressure forceps are taken and applied to the cystic duct a short distance from the point where it joins the common bile duct. The cystic duct is then cut through between the points of application of the curved forceps, and next the cystic artery and vein are seized with forceps as they lie on the hepatic side of the cystic duct and divided in a manner similar to the cystic duct. Ligatures of chromicised catgut or silk are applied to the distal end of the cystic duct and to the divided blood vessels. The peritoneum on each side of the gall-bladder is next divided and the gall-bladder separated with the finger from the

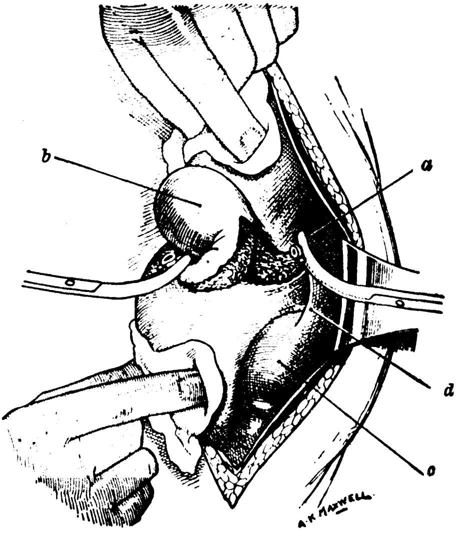

FIG. 174.—Cholecystectomy. Further stage of operation shown in Fig. 173. The cystic duct has been divided and the gall-bladder partially separated from the lower surface of the liver.

a. Cystic duct.
b. Gall-bladder.
c. Duodenum.
d. Free margin of gastro-hepatic omentum.

lower aspect of the liver. If any bleeding points are met with they are picked up with forceps and ligatured. This method of separation of the gall-bladder is preferable when the viscus is small, but if it is large or the patient has thick abdominal walls the former method is more convenient, since a shorter incision suffices. Occasionally, however, it will be found to be safer, when the gall-bladder is the seat of active suppuration and filled with a collection of pus and calculi, first to perform cholecystostomy and establish drainage, and at a later period to remove the gall-bladder. In such cases the tissues at the neck of the gall-bladder and along the cystic duct are infiltrated with inflammatory products, a condition which is not very favourable for removal of the gall-bladder and closure of the parietal wound. If possible, the mucous membrane of the divided portion of the cystic duct should be removed by scraping or cauterised with carbolic acid 90 per cent., especially when the gall-bladder is the seat of an inflammatory process. When this has been done, the margins of the wound in the peritoneum on the inferior surface of the liver are, if possible, brought together and fixed in apposition by the insertion of a continuous suture of chromicised catgut. The stump of the cystic duct is covered over with a flap of peritoneum as the continuous suture is being inserted. The area of operation is cleansed by careful sponging or local irrigation, and the parietal wound closed in the usual manner. If there is much bleeding it may be necessary to pack with plugs of gauze, the ends of which are brought out in an angle of the external wound, which is left open for the purpose.

Cholecyst-enterostomy.—Cholecyst-enterostomy is an operation which has for its object the creation of an artificial communication between the gall-bladder and the intestine, usually the duodenum.

Indications.—The operation of cholecyst-enterostomy appears to be indicated in the following conditions :—

(*a*) In all cases where the bile duct is permanently obstructed or occluded by adhesions, inflammatory processes, or malignant growths, the cystic duct remaining patent. The forms of new growth include those which are primary in the bile duct and those which commence in the head of the pancreas and spread to it by direct extension. In cases where the bile duct is occluded as the result of secondary malignant growths, it is not advisable to perform the operation.

(*b*) In all cases of complete division of the bile duct as the result of injury or operative measures, where a satisfactory end-to-end suture cannot be carried out, or the proximal end cannot be implanted in the adjacent portion of the duodenum.

(*c*) In cases of chronic biliary fistulæ which cannot be cured by the performance of a plastic operation, or in which the fistulæ are due to obstruction of the bile duct, and are not amenable to direct surgical interference.

(*d*) In all cases of perforation of the bile duct which result from an ulcerative process, and in which choledochostomy cannot be performed.

(*e*) In cases of kinking of the bile duct which are due to the presence of fibrous adhesions, and cannot be remedied by operation.

Special instruments.—Intestinal clamps and small "anastomosis button" (Murphy's).

Position.—The patient is placed in the dorsal posture, the surgeon stands on the right side of the patient, and the assistant on the left.

Operation.—The operation may be divided into the following stages :—

(*a*) *Parietal incision.*—An incision is made in the right linea semilunaris, commencing at the costal margin and extending downwards for 2 or 3 inches. This is extended until the peritoneal cavity has been opened.

(*b*) *Finding and delivery of gall-bladder and duodenum, and union of same by suture.*—The margins of the parietal wound being well retracted, the gall-bladder and the second portion of the duodenum are brought forwards into the wound, and the surrounding portion of peritoneum and adjacent viscera packed away and protected with flat gauze pads. In certain cases in which it is difficult to approximate the duodenum and gall-bladder without tension, the stomach may be used instead of the duodenum. No discomfort follows from the constant trickle of bile into the stomach. Next, the gall-bladder, if distended with fluid, is emptied by a trocar and cannula or an aspirator and the aperture of puncture closed by a suture. The fundus of the gall-bladder and the second portion of duodenum are next separately grasped with a rubber-covered curved or straight clamp and the portions beyond the clamps held in close apposition by an assistant. The use of the clamp may be dispensed with if a trained assistant is available who can hold close together the fundus of the gall-bladder and the duodenum whilst the suturing is being effected. A fine needle threaded with No. 1 silk is now taken, and a continuous suture inserted for a distance of a little more than one inch where the two viscera lie in contact. This suture should only pick up the serous, muscular, and submucous layers of the gall-bladder and duodenum, and when the extremity has been reached it is knotted and laid aside, still threaded to the needle. Two parallel incisions are now made into the lumina of the approximated portions of the gall-bladder and duodenum, each incision being a little more than one quarter of an inch from and parallel with the suture already introduced and nearly one inch in length. The margins of these incisions are pared with scissors, and then sutured by a continuous suture of No. 1 chromicised catgut, the entire thickness of the wall of both gall-bladder and duodenum being included. This suture passes entirely around the openings made into the duodenum and gall-bladder, and ought to have several interruptions in its course in order to avoid leakage as far as possible from either the gall-bladder or the duodenum. The rubber-covered clamps are next removed, the surfaces of the gall-bladder and duodenum carefully sponged, and the needle armed with the silk suture taken up, and the line of suturing continued around the anterior margin of the newly established communication. If there is any doubt concerning the security of the suturing, a few points of interrupted silk suture may be introduced at intervals so as to strengthen the approximation. The exposed portions of the gall-bladder and the duodenum are again sponged dry, and the protecting gauze pads removed. The gall-bladder and duodenum are next replaced within the abdominal cavity in their usual position, care being taken not to allow twisting.

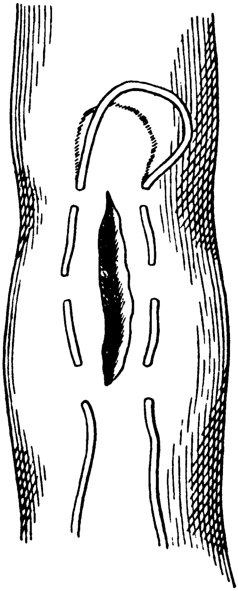

FIG. 175.—Method of inserting " purse-string suture " into intestine in the operation of cholecyst-enterostomy.—After MURPHY.

This, in my opinion, is the easiest and best method of performing cholecyst-enterostomy. Some surgeons, however, prefer to establish the anastomosis with the aid of a mechanical appliance such as Murphy's " anastomosis button." As this is practically the only operation in which an " anastomosis button " is now used, I give the details of this method of procedure, although I do not recommend it.

With the aid of an assistant, the gall-bladder and the commencement of the second part of the duodenum are drawn up into the wound, and a purse-string suture of silk is inserted in each of them, beginning with that in the intestine. This is done in the following manner:—The anterior aspect of the bowel is chosen, and, commencing from above, the suture is inserted for a distance of about 2 inches in a line corresponding with the long axis of the intestine by means of an in-and-out movement of the needle, all the coats of the duodenum being taken up (Fig. 175). A loop of silk 3 inches long is then left here, and the return part of the suture is made in a similar manner. The two lines of suture are parallel, and should be situated about half an inch apart. This suture thus introduced forms a running thread, which, when tightened, draws the incised edge of the bowel within the cup of the "anastomosis button." A similar suture is inserted in the fundus of the gall-bladder. A vertical incision, which is two-thirds of the diameter of the "anastomosis button," is now made in the duodenum between the two lines

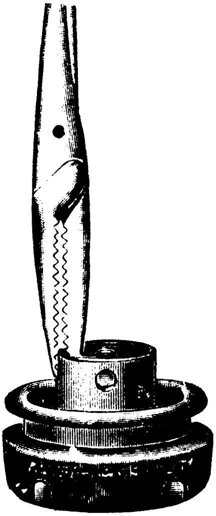

Fig. 176.—Cholecyst-enterostomy. Method of holding male portion of anastomosis button for insertion.

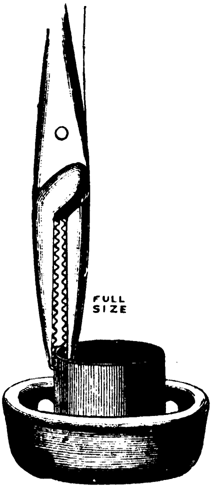

Fig. 177.—Cholecyst-enterostomy. Method of holding female portion of anastomosis button for insertion.

of suture, care being taken to avoid cutting the running thread when making the incision; the male half of the "button" is slipped in, the running thread tied firmly around the central cylinder, and then the button is given to an assistant to hold with forceps, so as to prevent it slipping into the cavity of the bowel. An incision is now made in the gall-bladder, the same length as the one in the intestine, between the two rows of suture. The contents of the gall bladder are removed, the female half of the "button" inserted, and the running thread tied. The forceps are then removed, the two halves of the "button" are held between the fingers and slowly pressed together. A sufficient degree of pressure must be used to bring the serous surfaces of the gall-bladder and intestine firmly in apposition and compress the tissues. After the "button" has been inserted, a circle of interrupted sutures of fine silk should be put in, each suture taking up the serous, muscular, and submucous coats both of gall-bladder and of duodenum. This will strengthen the line of union, and will prevent leakage in cases where the "button" cuts

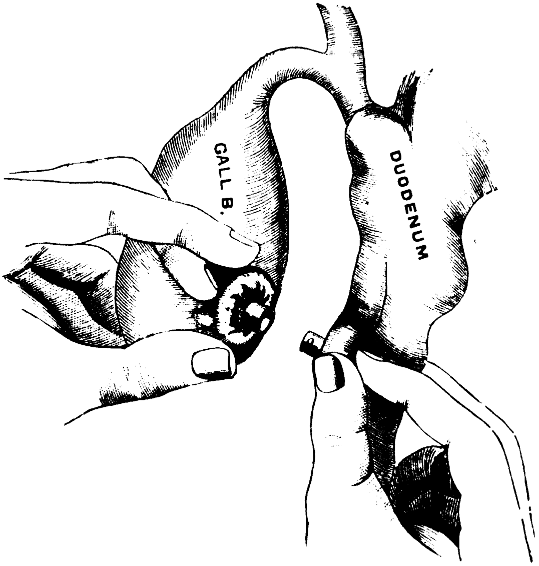

FIG. 178.—Cholecyst-enterostomy. Gall-bladder and duodenum, showing two halves of anastomosis button introduced, with the "purse-string" sutures tied, and ready for fixing together.—After MURPHY.

through quickly. The elastic pressure of the spring cup of the "button" produces a pressure atrophy of the tissues embraced by it, and leaves an opening which is larger than the "button." When the "button" is liberated it passes on through the bowel, and is voided from eight to fourteen days after the operation.

(*c*) *Closure of the external wound.*—This is closed in the usual manner by the insertion of three tiers of sutures.

Cholecysto-Gastrostomy.—In this operation an anastomosis is made between the gall bladder and the adjacent portion of the stomach. The details of the operation are similar to those of cholecysto-enterotomy, with the exception that the anterior aspect of the stomach is used in place of the duodenum or "jejunum."

Choledocho-lithotomy—choledochotomy.—This operation has for its object the removal of one or more calculi from the interior of the bile duct, in cases in which an obstruction to the flow of bile along this canal has been established, or in which symptoms result from the impaction.

Position.—The patient is placed in the dorsal position. The operator stands on the right and the assistant on the left. The lumbar rest of the operating table is first raised, or a large sand-bag, or "shaped lumbar block," placed underneath the lower dorsal region, so as to throw the lower dorsal and lumbar spine forwards. This very much facilitates manipulations in connection with the bile duct.

Operation.—The operation in its performance may be divided into the following stages, namely:—

(*a*) *Parietal incision.*—The abdominal cavity is opened by an incision which is made either a little to the right of the linea alba, beginning immediately below the xiphoid process (ensiform cartilage), or through the right rectus muscle, a little medial to its lateral margin, commencing just below the costal arch. It is not always possible to make an exact diagnosis as regards the seat of the impacted calculi, and when this is the case it is better to make the incision through the middle of the right rectus abdominis muscle.

(*b*) *Exposure of bile duct, location of calculus or calculi, incision of bile duct, and extraction of calculus or calculi.*—When the abdominal cavity has been opened, the course of the biliary tract is examined with the finger; the gall-bladder should be examined first, then the cystic duct, and then the bile duct, not only where it lies in the hepato-gastric ligament (small omentum), but also in its course behind the first part of the duodenum, and between and behind the head of the pancreas and the left aspect of the second portion of the duodenum. In many cases, placing the examining finger in the epiploic foramen (foramen of Winslow) will be found to be of diagnostic value, since in this position a considerable extent of the bile duct can be palpated, and if there is a calculus in its interior its position can be made out at once. When a stone is discovered in the bile duct, the hepato-gastric ligament and the bile duct are

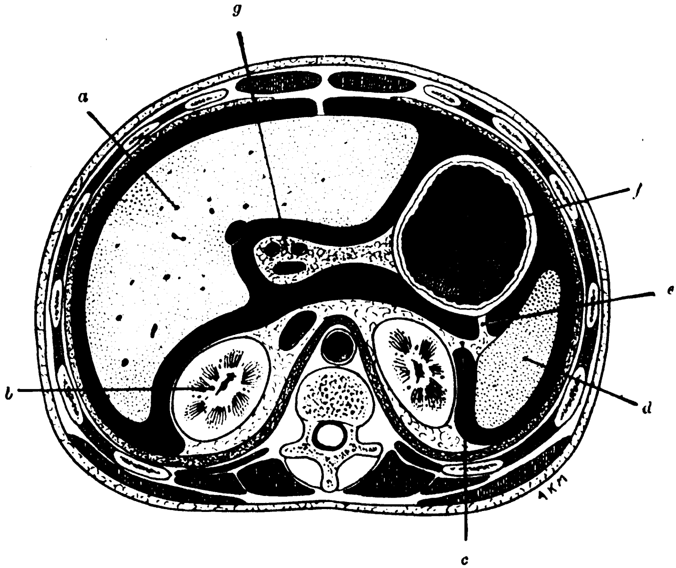

FIG. 179.—Relation of structures in hepato-gastric ligament.

a. Liver.
b. Right kidney.
c. Lieno-renal ligament.
d. Spleen.
e. Gastro-splenic ligament (O.T. gastro-splenic omentum).
f. Stomach.
g. Gastro-hepatic ligament (small omentum).

drawn into the abdominal wound. The peritoneal cavity around these structures is packed with gauze sponges, and an incision is made in the bile duct over the calculus after the peritoneum, which forms the anterior layer of the hepato-gastric ligament (small omentum), has been divided, this incision being parallel to the long axis of the duct. Through this opening the impacted calculus is extracted, care being taken to damage the walls of the duct as little as possible. In order to facilitate the removal of the calculus, it is found in some cases to be advantageous to break up the stone with crushing forceps, and extract it in several fragments.

(*c*) *Suture of opening in bile duct, and establishment of drainage if considered necessary.*—The stone having been removed, the area of operation is thoroughly sponged, and the margins of the incision in the bile duct are then approximated and fixed in apposition by the insertion of two tiers of fine sutures. The sutures which include the mucous membrane should be of fine chromicised catgut, those which pass through the superficial tissues either silk or catgut. Silk sutures passed through the mucous membrane favour the development of another gallstone. The first tier unites the margins of the incision and passes through mucous membrane, and the muscular and fibrous coats. In the second tier each suture transfixes the muscular and fibrous coats only of the duct, and is inserted in Lembert's manner. If the peritoneum which forms the anterior layer of the hepato-gastric ligament (small omentum) has been dissected from the bile duct, it should be united separately from the muscular walls of the bile duct, in which case three tiers of sutures will be requisite. In many cases of this operation it will be found advisable to pack the region of the incision in the bile duct with a strip of gauze, bringing out the end of this strip through an angle of the abdominal wound, which is left open for the purpose. This strip is removed after one or two days, and if there is no sign of leakage from the duct the abdominal wound is entirely

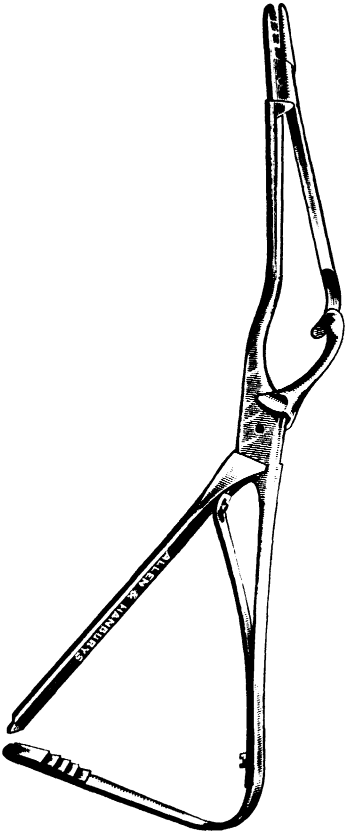

FIG. 180.—Needle-holder for sewing up an incision in the bile duct.

closed. The strip of gauze is replaced by a similar one when any small quantity of fluid escapes. When, however, there is evidence of ulceration or suppuration in the bile duct, a rubber tube should be fixed to the margins of the opening in the bile duct by catgut sutures, and brought out through a portion of the parietal wound, which is left open for the purpose. This will enable free drainage to be established, and probably avoid general peritonitis. As the local condition improves, the tube can be replaced by a smaller one, and finally left off altogether, when the fistula will close.

It is sometimes found that the impacted calculus lies behind the duodenum, and then it is necessary to lift up this structure and open the bile duct, as it lies behind it. If the calculus is a small one, or the bile duct is considerably dilated, an attempt may be made to manipulate the calculus into the duodenum, by forcing it along the duct and through the orifice of the biliary papilla. In another method a vertical incision is made through the anterior wall of the duodenum, and the termination of the bile duct enlarged so as to enable the calculus to be extracted.

(*d*) *Closure of parietal wound.*—All sponges and pads are removed from the peritoneal cavity, the area of operation carefully sponged, and then the margins of the parietal incision are united by the insertion of three tiers of sutures in the usual manner, except when it is considered necessary to establish drainage, in which case a portion is left unsutured.

CHAPTER VII

OPERATIONS UPON THE SPLEEN

THE following are the operations which may be performed upon the spleen :—

SPLENECTOMY.
SPLENOTOMY.
SPLENOPEXY.
TREATMENT OF RUPTURES AND WOUNDS.

Removal of the spleen, or splenectomy.—In this operation the spleen is removed through an incision in the anterior or antero-lateral abdominal wall.

Indications.—Removal of the spleen is indicated in the following clinical conditions :—

(*a*) Certain cases of rupture of the organ, due to some form of injury, such as a blow upon the abdomen, or a stab, or to spontaneous rupture, in which hæmorrhage cannot be arrested by milder measures.

(*b*) Some forms of cystic affections which are not amenable to drainage.

(*c*) Some forms of "movable" or "wandering" spleen, in which the viscus cannot be retained in position by a suitable belt, or cannot be fixed in its usual place by a surgical operation.

(*d*) Some forms of hypertrophy, either simple or malarial in nature, which cannot be relieved by other measures.

(*e*) Occasional cases of suppuration or inflammation. Malignant disease of the spleen appears to contra-indicate removal, since it is usually secondary. When, however, primary and there is no secondary growth it should be removed.

(*f*) In many cases of acholuric jaundice associated with enlargement of the spleen.

(*g*) The early stages of splenic anæmia and Barty's disease.

(*h*) Certain rare blood diseases, *e.g.* polycythæmia with splenomegaly.

Location.—The spleen is a solid viscus, situated upon the anterior aspect of the posterior abdominal wall. It lies in the left portion of the epigastric region and upper part of the left hypochondrium, about one-third being in the former and two-thirds in the latter. It lies obliquely, its upper extremity being nearer the middle line than the lower. The diaphragm and the posterior inferior margin of the left lung and pleura intervene between it and the inner surfaces of the ninth, tenth, and eleventh ribs. The splenic artery enters, and the splenic vein emerges, from the hilum. The viscus is attached to the left margin of the stomach by the lieno-gastric ligament (gastro-splenic omentum), and to the left kidney by the lieno-renal ligament; these folds unite above in the phrenico-splenic ligament, thus attaching it to the diaphragm. The tail of the pancreas lies in close relation to the hilum.

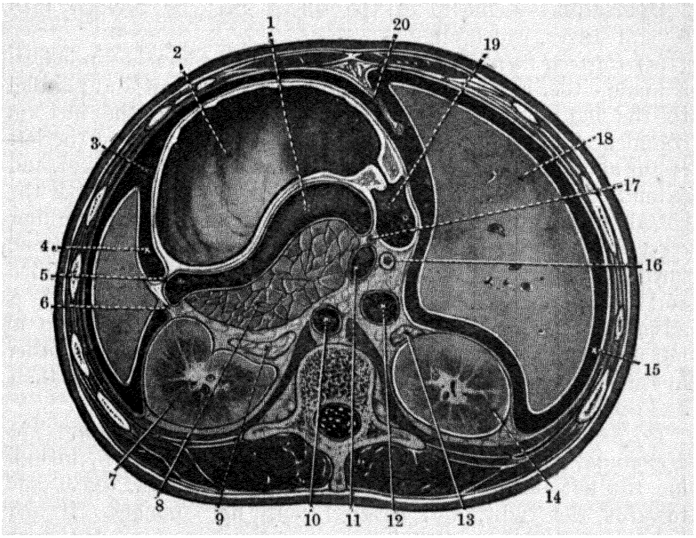

FIG. 181.—Transverse section of the body, to show relations of spleen to adjacent viscera. (Seen from above.)

1. Omental bursa (O.T. lesser sac).
2. Stomach.
3. Great sac.
4. Great sac.
5. Gastro-splenic ligament (O.T. gastro-splenic omentum).
6. Lieno-renal ligament.
7. Left kidney.
8. Pancreas.
9. Left suprarenal gland.
10. Aorta.
11. Portal vein.
12. Inferior vena cava.
13. Right suprarenal gland.
14. Right kidney.
15. Great sac.
16. Bile duct.
17. Gastro-duodenal artery.
18. Liver.
19. Duodenum, first part.
20. Falciform ligament.

Special instruments.—Large clamp forceps, sponge-holders, needle on handle with blunt point.

Position.—The patient is placed in the dorsal position, or, when the antero-lateral incision is employed, lying slightly upon the right side. The surgeon stands on the left side, and the first assistant directly opposite to him.

Operation.—Removal of the spleen may be divided into several stages, which are—

(*a*) *Parietal incision.*—An incision from 4 to 5 inches in length is made either in the left linea semilunaris, or below and parallel to the left costal margin. In the latter case the incision commences immediately lateral to the lateral border of the left rectus abdominis muscle, and 1 inch below the costal margin, and extends downwards and backwards in a line parallel with the costal margin to the interval between the last rib and the iliac crest. Whichever incision is made use of, the wound is deepened until the various strata of the abdominal wall have been divided and the peritoneal cavity opened. In most instances it is advisable to adopt the incision in the linea semilunaris, but in fat and emphysematous people with deep chests the other incision will enable the operator more easily to get at the pedicle and apply a ligature to it.

(*b*) *Separation of adhesions and delivery of spleen.*—The abdominal cavity having been opened, the intestines, including the left flexure of the colon, are pushed downwards and towards the right, and covered with flat sponges. If any adhesions are present they are defined, surrounded with ligatures in two places, and divided between. When all adhesions have been divided, the spleen is carefully lifted up from its position underneath the ribs into the external wound. Its pedicle is then defined. Usually this will be found to be broad and extensive, and have important connections. It consists of four laminæ of peritoneum—the two layers which form the lieno-gastric ligament (gastric-splenic omentum) and the two layers of the lieno-renal ligament.

(*c*) *Ligature of pedicle and removal of spleen.*—The structures which form the pedicle having been defined, the lesser sac of the peritoneum should be opened a little below the greater curvature of the stomach, where it lies nearest to the spleen. When this has been done the lieno-gastric ligament can be seized with several pairs of pressure forceps for its entire length and cut through. When this has been done, the stomach is pushed farther to the right and the posterior half of the splenic pedicle fully defined. It will be found to consist of a lieno-renal ligament and the main splenic blood vessels. Often the apex of the tail of the pancreas will be found extending between the layers of the lieno-renal ligament almost as far as the hilum of the spleen. Next the lieno-renal ligament and the structures in it—the splenic artery and the splenic vein—are each seized with two pairs of pressure forceps and divided between. When the posterior portion of the pedicle has thus been divided it will be found that the spleen is free and can be taken away. Next, the splenic artery, the splenic vein, and the portions of the lieno-renal ligament which have been seized with pressure forceps are securely tied with ligatures of No. 2 silk or chromicised catgut. Personally, I think silk is the better ligature material for occlusion of the splenic artery and vein. When the main splenic blood vessels and lieno-renal ligament have been ligatured, the lieno-gastric ligament and its contained blood vessels—vasa brevia—are ligatured in a similar manner. It is advisable when ligaturing the portions of the lieno-renal and lieno-gastric ligaments to leave the ends of the sutures at first long; then after the lieno-gastric ligament has been ligatured one end of each lieno-gastric ligature is tied to one end of the corresponding portion of a lieno-renal ligature. By adopting this method of ligature and suture the lesser sac of the peritoneum is reconstituted, and no abnormal opening is left through which a portion of the omentum or intestine can be prolapsed at a later period. When removing the spleen in the method above described the operator will often observe one or more accessory or supernumerary spleens between the layers of the lieno-renal ligament or immediately below it. These should be left behind. After all ligatures have been tied, the region of the pedicle of the spleen is again sponged carefully dry so as to remove all blood, etc., from the peritoneal cavity. Next, the sponges and gauze packing are removed from the peritoneum; and the stomach, intestines, and omentum allowed to fall back into their usual position.

(*d*) *Closure of external wound.*—This is effected in the usual manner by the insertion of several tiers of sutures. If there is much oozing, it is advisable to pack the space from which the spleen has been removed with a long strip of gauze, one extremity of which is brought out through an angle of the external wound, which is left open for the purpose.

The chief danger in the operation of splenectomy is the liability to the occurrence of severe hæmorrhage. The most favourable cases are those in which the viscus is removed for injury.

Splenotomy, or incision of the spleen.—This operation may be necessary in some cases of abscess of the viscus, in which the inflammatory process has extended to the surrounding tissues and caused the formation of numerous adhesions. An incision is made through the abdominal wall over the most prominent part of the inflammatory swelling, until the abscess cavity is reached.

The general peritoneal cavity is then shut off with sponges if it has been opened, the viscus brought into the wound, and the cavity opened and the contents evacuated. A sponge is then inserted into this incision, those shutting off the surrounding peritoneal cavity removed, and the edges of the incisions in the spleen and parietes united with interrupted sutures, the wound packed with gauze, and dressing applied.

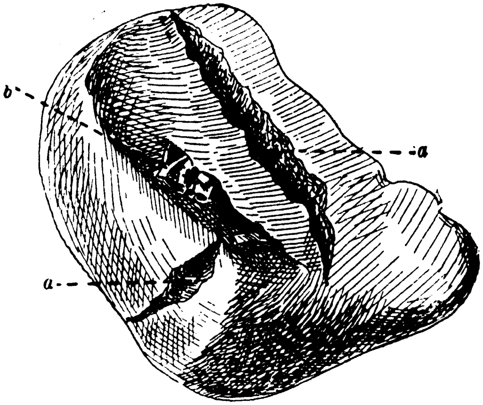

FIG. 182.—Spleen showing two ruptures or lacerations.
a. Rupture. *b.* Splenic vessels.

Splenopexy.—This operation has been performed on account of a wandering or movable spleen not associated with enlargement or any form of disease.

Operation.—The abdomen is opened by an incision 4 inches long in the upper part of the left linea semilunaris, the stomach and large intestine are pushed over towards the right, covered with flat gauze sponges, and held out of the way by an assistant. The spleen is defined, and the exact amount of its mobility determined, and it is ascertained whether it can be readily replaced in the left hypochondriac region without tension of the pedicle. This having been done, the spleen is held out of the way towards the right, the left margin of the parietal wound strongly retracted, and a vertical incision made through the parietal peritoneum, commencing above at the level of the tenth rib and extending downwards on the lateral side of the splenic flexure and descending portions of the colon, for 3 inches or more. With the fingers the peritoneum is separated from its diaphragmatic and parietal connections, and a retro-peritoneal pouch formed sufficiently large to hold the spleen. The margins of the incision in the peritoneum are separated, and the spleen placed in the newly formed retro-peritoneal pouch. The margins of the lower portion of the incision in the peritoneum are next united with a few points of interrupted suture, care being taken not to sew up so much of the opening as to constrict the splenic blood vessels. The area of operation is next sponged dry, the protecting pads and sponges removed, the stomach and intestines replaced in their usual position, and finally the parietal wound closed in the usual manner by the introduction of three tiers of sutures.

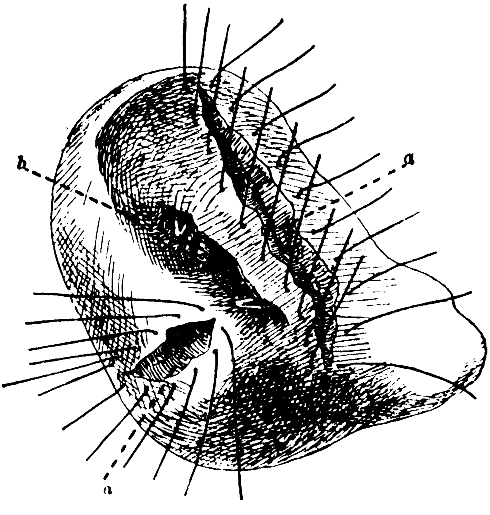

FIG. 183.—Spleen showing two ruptures. Sutures have been introduced to close ruptures.

a. Rupture and sutures inserted. *b.* Splenic blood vessels.

A similar operation has been done through an incision in the left lumbar region as for movable kidney, the peritoneum being opened outside the upper portion of the kidney, and a pouch formed as above. This form of operation is not so easy to perform as the one described above, and generally requires a much larger incision. For these reasons the abdominal method is recommended.

Ruptures and wounds of the spleen.—*Indications.*—Rupture of the spleen is occasionally met with as the result of violence. The symptoms presented by the patient are those of internal hæmorrhage and shock, and the presence of a fluctuating swelling in the left lumbar and hypochondriac regions. Whenever a diagnosis is made that a patient is suffering from a rupture of the spleen and consequent intra-peritoneal hæmorrhage, an operation for the relief of the condition should be carried out with as little delay as possible. Often the exact nature of the intra-abdominal injury will only become apparent after the peritoneal cavity has been opened.

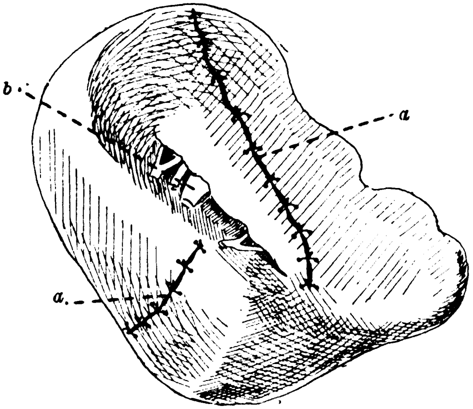

FIG. 184.—Spleen showing two ruptures which have been closed by suture.
a. Rupture closed by suture. *b.* Splenic vessels.

Operation.—The peritoneal cavity should be opened above the umbilicus, through an incision 3 to 3½ inches long, and situated either a little to the left of the middle line or in the left linea semilunaris. The latter incision should only be adopted when the physical signs definitely locate the injury in the left hypochondrium or the left lumbar region. When the peritoneal cavity has been opened, all blood or blood-clot should be quickly sponged away, and the hand introduced and passed upwards and towards the left into the left hypochondrium, in order to palpate carefully the surfaces of the spleen, and to detect any solution of continuity upon its surface and in its substance. When these are located the entire viscus is brought into the parietal wound—a proceeding which is facilitated by exerting strong traction upon the left margin of the incision with a large abdominal retractor—and the extent of the injury made out. If the viscus is severely lacerated, or a portion almost detached, the entire organ should be removed according to the method already described (p. 236). If the injuries do not involve more than one-half the thickness of the organ, and there are no detached portions, the rent should be closed by the insertion of a series of sutures, each suture entering one-third of an inch from the margin of the tear, extending through the splenic substance to just beyond the bottom of the tear, and emerging a similar distance beyond the opposite margin. Moderately thick silk or catgut should be used for this purpose. The sutures should be one-sixth to one-eighth of an inch apart, and all should be inserted before any are tied. They are tied in such a manner that the margins of the tear or rupture are brought into complete and firm apposition, whilst the splenic substance is not torn by the sutures themselves. Hæmorrhage from any torn branches of the splenic artery or vein, or from the splenic substance, can be controlled during the suturing by an assistant grasping the lieno-gastric ligament and exerting pressure on the splenic artery and vein, especially the former. If any large branches of the splenic artery are torn across, each should be picked up separately with pressure forceps and ligatured with silk. When the repair of the injuries has been completed, the surface of the viscus and the adjacent peritoneum are sponged free of blood, the spleen is returned into the abdominal cavity, and the parietal wound closed in the usual manner. The essential elements for success in this operation are—first, early operation; and secondly, control of the circulation through the splenic artery by digital pressure until the suturing is completed. I have performed this operation with complete success on a boy who had sustained an extensive double rupture of the spleen. Figs. 182, 183, and 184 illustrate the closure of a rupture of the spleen.

Some surgeons recommend that when the region of the injury to the splenic tissue has been exposed it should be thoroughly packed with strips of gauze. I do not see any objection to this method of treatment, but think the suture method is the better, as it more completely arrests hæmorrhage, and does not leave a large wound which has to close by granulation.

Perforating wounds of the spleen, such as stabs and gunshot wounds, which necessitate operative interference, are treated by enlarging the external wound until the injured viscus is exposed, and then treating it according to the methods described above. In many cases of perforating wounds of this kind in the lumbar region it will be found advisable to commence, as described above, by opening the abdomen from the front, since, if the wound is deep and extends forwards, a more satisfactory and complete exposure of the injured parts is obtained.

CHAPTER VIII

OPERATIONS UPON THE PANCREAS

THE pancreas is an elongated solid glandular structure placed transversely across the upper portion of the abdominal cavity at the level of the second lumbar vertebra and behind the posterior layer of the parietal peritoneum. It extends from the concavity of the duodenum on the right to the hilum of the spleen on the left, and occupies portions of the lower epigastric, umbilical, and left hypochondriac regions. Posteriorly it lies in close relation to the lower part of the bile duct, inferior vena cava, abdominal aorta, left renal vessels, left kidney and suprarenal gland, and the hilum of the spleen. In front lie the omental bursa (lesser sac), portions of the posterior aspect of the stomach, the hepato-gastric ligament (small omentum), the gastro-colic omentum (great omentum), and towards the left the lieno-gastric ligament (gastro-splenic omentum). The best method of surgical approach is through the anterior abdominal wall, an incision being made either in the middle line immediately above the umbilicus or through the left linea semilunaris, the former in most cases being the more suitable. After opening the abdominal cavity the best method of exposure is through the gastro-colic omentum (great omentum) and the omental bursa (lesser sac). Attempts have been made to operate upon conditions of the pancreas via the lumbar region, but this route has been found to be unsatisfactory and difficult owing to the great depth of the organ to be exposed and the intimate relationships to important anatomical structures.

Indications.—The most important affections which necessitate exposure of the pancreas are comprised in the following groups of pathological conditions :—

(*a*) Cysts of the pancreas. These cysts may develop in connection with any portion of the pancreas, and project forwards towards the anterior abdominal wall, usually pushing upwards or downwards the stomach or transverse colon, (*b*) Acute pancreatitis—suppurative or hæmorrhagic. These affections should be submitted to surgical interference immediately the diagnosis has been made.

(*c*) Chronic pancreatitis with the formation of an abscess.

(*d*) Calculus blocking the duct of the pancreas.

(*e*) Localised malignant growths of the pancreas, usually carcinomata, which have not invaded adjacent structures, and are not associated with secondary deposits in distant lymph glands or viscera. It rarely happens that a malignant growth of the pancreas is diagnosed sufficiently early to allow complete removal with a good prospect of success. On two occasions I have removed malignant growths of the pancreas, but in each case with an unsatisfactory result.

The pancreas is a very vascular organ, and is sparsely provided with connective tissue, hence it is very liable to hæmorrhage when cut or damaged ; extreme caution therefore must be practised when carrying out surgical procedures upon or immediately adjacent to it, otherwise severe hæmorrhage may be induced.

Position.—The patient is placed in the dorsal posture, and a long, narrow hard sandbag placed underneath the lumbar portion of the spinal column. The operator stands on the right side of the patient and the assistant directly opposite to him.

Operation.—*Abdominal incision, exposure of anterior aspect of stomach, gastro-colic omentum (great omentum), hepato-gastric ligament (small omentum), and determination of best method of surgical approach.*—An incision is made in the middle line 3 inches in length, which commences above in the epigastric region and terminates below immediately above the umbilicus. When the condition for which an operation is performed is a cyst of the pancreas, and this cyst protrudes forwards so as to form an eminence some distance from the middle line, then the incision should be made vertically over the most prominent part of the swelling. The various strata of the anterior abdominal wall are cut through until the parietal peritoneum is exposed. This is incised for the entire length of the incision, and the abdominal cavity thus opened. The presence or absence of peritoneal adhesions is noted, and the position and relations of any swelling made out. If cases of supposed acute suppurative or hæmorrhagic pancreatitis are under consideration, careful notice should be taken of the peritoneum in order to detect areas of fat necrosis, since when present they usually denote that the pancreas is the seat of an acute affection. These patches can readily be recognised by their yellowish-white colour and the fact that they are of various sizes and located in the extra-peritoneal omental and mesenteric tissues. Another sign of great importance is the presence of blood-stained fluid either in the general peritoneal cavity or in the omental bursa (lesser sac). The latter is the usual seat, and recognition can readily be made by observing a red or purple discoloration between the layers of the large omentum. When a pancreatic cyst bulges forwards, and at the same time forces the stomach downwards, a prominence is formed immediately above the small curvature of the stomach, in which case it should be decided to deal with the cyst after dividing the hepato-gastric ligament (small omentum). In most cases of cyst, however, and in practically all cases of pancreatic abscess, or acute suppurative hæmorrhagic or gangrenous pancreatitis, it is advisable to approach the pancreas through the omental bursa (lesser sac) after dividing the gastro-colic omentum (great omentum) just below the large curvature of the stomach.

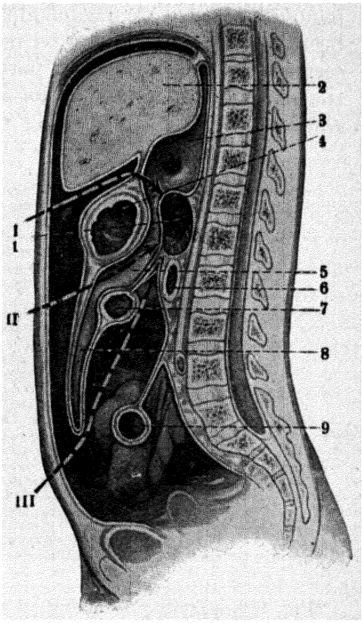

Fig. 185. — Diagrammatic section through abdomen, showing important anatomical and surgical points.

1. Pancreas.
2. Liver.
3. Omental bursa (upper part).
4. Stomach.
5. Omental bursa (lower part).
6. Duodenum.
7. Transverse colon.
8. Omental bursa (omental part).
9. Pelvic colon.

I. Route of approach through hepato-gastric ligament.
II. Route of approach through gastro-colic omentum of lesser sac.
III. Route of approach through transverse-meso-colon.

(*b*) *Division of gastro-colic omentum (great omentum), opening of omental bursa (lesser sac), incision of posterior layer of parietal peritoneum, exposure of pancreatic cyst abscess or other pathological condition.*— The peritoneum forming the gastro-colic omentum (great omentum) is torn through with a blunt director in a vertical direction for 2 inches in order to open the omental bursa (lesser sac); care being taken to avoid any of the large blood vessels along the lower border of the stomach; and if any are injured they are at once ligatured. Next, the stomach is turned upwards, the margins of the incision in the gastrocolic (great) omentum retracted, and the anterior aspect of the pancreas laid bare. The conditions for which an operation has been performed can now be recognised. If a cyst, it will be seen as a rounded swelling partially embedded in a portion of the pancreas and extending forwards ; if a chronic abscess, there will be a localised fluctuating swelling usually in the region of the head and with adhesions ; whilst, if some variety of acute pancreatitis, the pancreas will be seen to be either dark purplish in colour or grey and gangrenous.

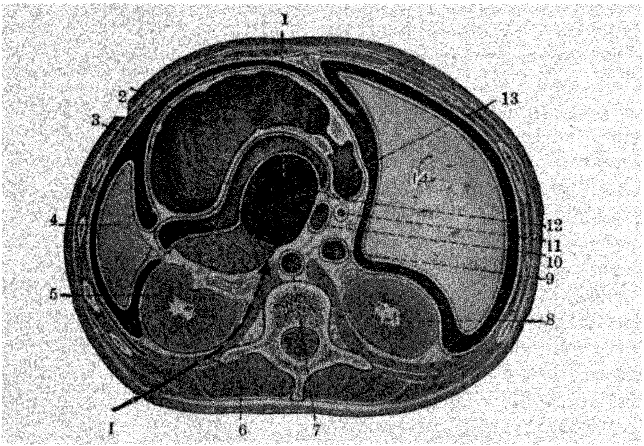

FIG. 186.—Transverse section of abdomen at level of second lumbar vertebra. (Seen from above.)

I. Route of approach from lumbar region.

1. Pancreas.
2. Stomach.
3. Omental bursa (lesser sac).
4. Spleen.
5. Left kidney.
6. Sacro-spinalis (erector spinæ).
7. Aorta.
8. Right kidney.
9. Inferior vena cava.
10. Portal vein.
11. Bile duct.
12. Hepatic artery.
13. Duodenum.
14. Liver.

(*c*) *Treatment of pathological condition discovered after exposure.*—When the pathological condition met with is a cyst, this, if small, can occasionally be entirely removed by dissecting it out from the fibrous tissue capsule and portion of pancreas in which it lies. If this is feasible, after removal of the cyst the walls of the space from which it has been taken should be obliterated as far as possible by sutures, and in addition all bleeding points, which may be numerous, ligatured. In all cases a small drainage tube should be passed down to the bottom of the cavity and brought out through a portion of the parietal wound. This precaution is rendered necessary by the practical impossibility of ensuring non-escape of pancreatic secretion into a portion of the field of operation. If the cyst be large or its connections to adjacent structures considerable, then the portion of the abdominal cavity around the cyst should be carefully packed with flat gauze pads in order to avoid contamination, and its prominent part incised. The contents are evacuated, and finally the margins of the opening which has been made in the cyst sutured to those of a portion of the parietal incision. Cases of acute suppurative or hæmorrhagic pancreatitis are treated in a somewhat similar manner. After the superficial aspect of the pancreas has been exposed and the adjacent portions of the peritoneal cavity suitably protected, an incision is made into the affected portion of the organ, and all purulent matter, fragments of necrosed pancreas, and blood, removed. The space thus opened is packed with gauze, and then the margins of the abscess cavity fixed by a few points of suture to those of the incision in the anterior abdominal wall. A drainage tube is also passed into the space and brought out through the external wound. Chronic abscesses of the pancreas are treated in a similar manner, but in these cases adhesions will often be found to have formed in front, which facilitates the establishment of drainage. Whichever of the above procedures has been carried out, in all cases the portion of the parietal wound which is not required for the establishment of efficient drainage is closed by suturing in three tiers.

Cases of chronic pancreatitis which are due to spread of infection from the biliary passages or the duodenum are best treated by cholecystostomy and drainage of the gall-bladder after any gall-stone which may be present in the duodenal papilla or the lower end of the bile duct has been removed.

CHAPTER IX

OPERATIONS UPON THE URINARY SYSTEM

OPERATIONS UPON THE KIDNEYS.
- Nephrolithotomy.
- Nephrotomy.
- Nephrectomy.
  - 1. Lumbar. 2. Abdominal.
- Nephrorrhaphy.

OPERATIONS UPON THE URETERS.
- Ureterotomy.
  - 1. Lumbar. 2. Pelvic. 3. Vesical.
- Ureteroplasty.
- Ureterectomy.
- Uretero-ureteral anastomosis.
  - 1. End to end. 2. End in end. 3. Lateral.
- Uretero-vesical anastomosis.

OPERATIONS UPON THE URINARY BLADDER.
- Puncture of the bladder (suprapubic).
- Litholapaxy (lithotrity).
- Suprapubic cystotomy.
- Lateral lithotomy.
- Treatment of rupture of the bladder.

OPERATIONS UPON THE PROSTATE.
- Prostatectomy.
  - 1. Suprapubic. 2. Perineal.

OPERATIONS UPON THE URETHRA.
- Internal urethrotomy.
- External urethrotomy (Wheelhouse's operation).
- For the treatment of ruptured urethra.
- Excision of a urethral stricture.

OPERATIONS UPON THE KIDNEYS

Nephrolithotomy.—Nephrolithotomy is an operation which has for its object the removal of a calculus from a kidney. It is carried out through an incision in the lumbar region of the affected side, and on this account is sometimes called " lumbar nephrolithotomy."

Indications.—The performance of the operation is indicated—

(*a*) In all cases in which it is certain that a calculus is situated either in the kidney substance or in the renal pelvis, provided that the opposite kidney is sufficiently healthy to allow of this being done without danger to life, and

(*b*) In cases of calculus anuria, where, if possible, the healthier of the two kidneys is operated upon, and, the stone having been removed, lumbar drainage is established.

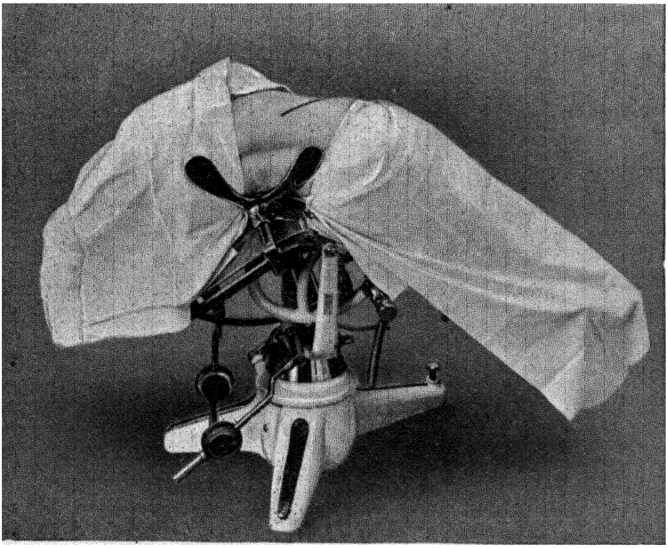

FIG. 187.—Nephrolithotomy. Position of patient and line of external incision.

Special instruments.—Retractors (wide), lithotomy forceps and scoop, long-bladed tenotome, long mounted needle, small short-beaked bladder sound (No. 3 E), and drainage tube.

Position.—The patient is placed in the semi-prone position, lying upon the sound side with the back near the edge of the operation table; the leg of the opposite side is then flexed upon the abdomen, and the underneath elbow drawn well backwards. The operation table is arranged as in Fig. 187, or if such a table is not available a moderate-sized sandbag or hard pillow is placed underneath the loin to open up the space between the crest of the ilium and the twelfth rib on the affected side. The surgeon stands behind the patient, and the chief assistant opposite him.

Operation.—The operation of nephrolithotomy may be conveniently divided into the following stages, namely :—

(*a*) *Parietal incision.*—An oblique incision is made in the lumbar region which is parallel to the lower border of the last rib and ½ inch below it ; it commences in front immediately above the crest of the ilium, and passes upwards and backwards to end at the lateral border of the sacro-spinalis (erector spinæ) in the posterior renal angle. The incision is usually about 4 inches in length at the beginning of the operation. Care must be taken to make certain of the position of the last rib by counting them from above, in order to avoid the pleura. Under ordinary circumstances, that portion of the right lower pleural recess which lies below the vertebral end of the twelfth rib is amply protected by the sacro-spinalis (erector spinæ), but it occasionally happens that the twelfth rib is very short and

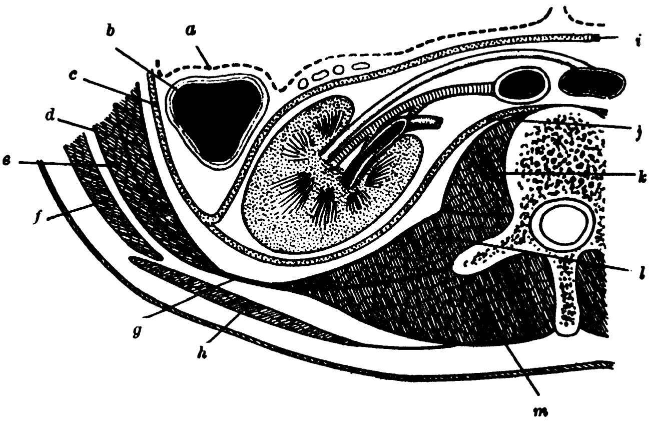

FIG. 188.—Transverse section of right lumbar region at level of kidney.

a. Peritoneum.	*g*. Lumbar fascia.
b. Colon.	*h*. Latissimus dorsi.
c. Fascia transversalis.	*i*. Perinephric fascia.
d. Transversus abdominis muscle (transversalis).	*j*. Post-nephric fascia.
e. Internal oblique muscle.	*k*. Psoas magnus muscle.
f. External oblique muscle.	*l*. Quadratus lumborum.
	m. Sacro-spinalis (erector spinæ).

rudimentary, and the eleventh is mistaken for it. In these cases, if the incision is made ½ inch below the eleventh costal arch, the lower portion of the pleura may be injured. The incision is deepened, the fasciæ being first divided, and then the muscular strata. The posterior fibres of the external oblique and the anterior fibres of the latissimus dorsi—both of them almost vertical in direction—are divided first; next, the internal oblique, and the posterior aponeurosis of the transversus muscle (transversalis), which in the medial portion of the incision splits to enclose the quadratus lumborum; finally, the post-nephric fascia, and, if requisite, the most lateral fibres of the quadratus lumborum, care being taken at this stage to avoid injury to the peritoneum, which is liable to injury in the anterior portion of the incision. The subcostal nerve and a branch of the first lumbar artery may be exposed in making the incision, and if met with they are pulled upwards with a retractor, so as to preserve them from injury.

(*b*) *Exposure of the kidney.*—When the post-nephric fascia has been divided, the fatty capsule of the kidney appears in the bottom of the wound. This is broken down with the finger or dissecting forceps, and by this means the posterior aspect of the kidney is laid bare. Large flat retractors (Fig. 189) are now used to separate the margins of the parietal incision, so as to expose the surface of the kidney more fully. If the kidney is movable in the perinephric tissue, it may tend to fall forwards, and so render its full exposure somewhat difficult. This difficulty may be avoided by directing the assistant to press the anterior abdominal wall upwards and backwards with the clenched fist of one or both hands. In this way the kidney can often be forced into the bottom of the wound.

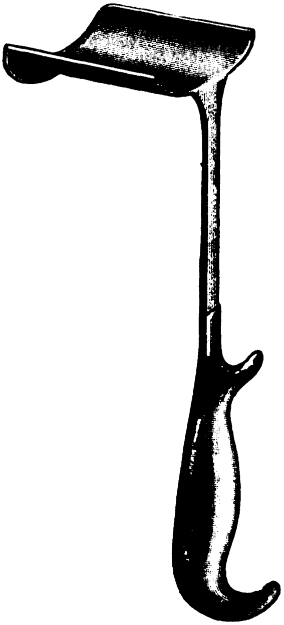

FIG. 189.—Broad abdominal retractor.

(*c*) *The examination of the kidney for the detection of a calculus.*—The kidney being supported from the front, either by the assistant or the hand of the surgeon, the whole of the posterior aspect is systematically palpated with the finger, and any irregularities or points of resistance noted. If a calculus is present it can occasionally be felt as a resistant body through the kidney substance. If nothing can be felt abnormal on the posterior aspect, the forefinger of the surgeon is passed round the lateral border of the organ, and the anterior surface examined. If nothing indicating the presence of a calculus is discovered by these manipulations, the kidney may be grasped between the forefinger and the thumb, and each part of it squeezed in the attempt to localise the stone. Next, the pelvis of the organ is examined from behind, the patient again being turned into the semi-prone position, if this has been changed. If all these measures fail, an incision should now be made into the lateral convex border of the gland with a long-bladed tenotome or scalpel. Before doing so, however, it is advisable to bring the kidney out on to the loin, or, failing this, to pass the left hand into the wound and round the hilum. This latter procedure will enable the surgeon to fix the kidney as well as to control all hæmorrhage by compressing the renal vessels between the contiguous margins of his index and middle fingers. Usually the position, shape, and size of the calculus or calculi will be known, from a skiagram which has been taken previously. This skiagram should always be available for inspection at the time of operation.

This incision, which should be limited to the middle third of the convex border, is deepened until the cavity of one of the calyces is opened. For the space of half a minute or so the hæmorrhage is very profuse, but it can be readily checked by packing a swab or strip of gauze into the gaping renal cortex, and by digital compression of the pedicle. The interior of the calyces and the pelvis of the kidney are now examined, first with a small steel sound, and then with the forefinger of the surgeon. This examination should be made in a systematic manner, commencing above and gradually working downwards until the commencement of the ureter has been reached. By one or other of these measures a calculus, if within the kidney or its pelvis, will generally be discovered. The ureter should now be carefully examined in the upper part of its abdominal course, and it is always advisable to pass a gum-elastic bougie (No. 3 E) through the renal wound and down the ureter into the bladder, to make sure that the lumen of the tube is not blocked lower down by an impacted stone. If the extra-renal portion of the pelvis is dilated, it is probably better to carry out the exploration by an incision into its posterior surface, rather than through one in the renal parenchyma. This incision should be in the line of the unstripped muscle of the pelvis, *i.e.* radiating from the hilum of the kidney towards the ureter. This procedure possesses the following advantages, viz.—(*a*) A more efficient investigation of the kidney can be carried out; (*b*) there is no hæmorrhage; (*c*) the pelvic opening of the ureter is more easily found with the point of the bougie; and (*d*) if the wound is carefully sutured with chromicised catgut a troublesome fistula is not more likely to result. The stone, having been located by one of the above methods, must be removed.

(*d*) *Removal of the calculus.*—If the kidney has not already been incised in the detection of the stone, an incision is made directly over the calculus with a scalpel or bistoury, the forefinger is passed into the wound, and the stone lifted out if possible. When this cannot readily be removed with the finger, a small pair of lithotomy forceps (Fig. 190) or a scoop is passed down to the region of the calculus, which is then seized and extracted. If the calculus is a branching one, it should be broken up into several fragments, each one being removed separately, to avoid unnecessary injury to the renal tissue. When the stone is within the pelvis of the kidney, it may be removed either through the incision in the renal tissue, or through an incision made through the posterior aspect of the renal pelvis; if the stone obstructs the commencement of the ureter, difficulty is often experienced in its extraction. By careful manipulation, however, it can be usually successfully removed.

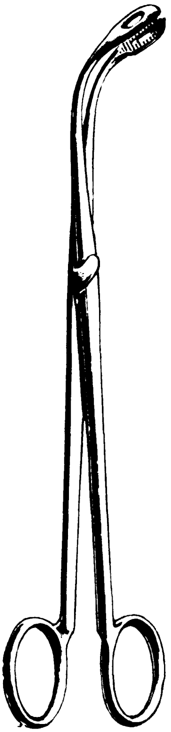
FIG. 190.—Calculus forceps for extracting calculi from the pelvis of the kidney.

When all fragments of the stone or stones have been removed, the wound in the kidney and the entire area of operation is irrigated with saline solution, so as to remove all blood, portions of calculus, and débris. If any distinct bleeding points become apparent they are ligatured with fine catgut. General venous oozing can be controlled and arrested by packing with tampons of gauze.

(*e*) *Treatment of the wound in the kidney, and closure of the parietal incision.*—The wound in the kidney is closed by three or four interrupted sutures of No. 2 chromicised catgut, which are passed deeply into the renal parenchyma, and are tied sufficiently tightly to arrest all hæmorrhage without causing necrosis of the renal tissue. A rubber drainage tube is now passed down to the region of the incision in the kidney, but not into it, and fixed in position by suturing it to one margin of the parietal incision. Next, the external wound is closed by two tiers of interrupted sutures; the first row are of chromicised catgut, and bring the cut margins of the internal oblique and transversus together; the second tier are of strong salmon-gut, and pick up the edges of the external oblique and latissimus dorsi in addition to the skin and superficial fascia. The drainage tube can usually be removed with safety in from two to three days, and the lumbar sinus allowed to heal.

Nephrotomy.—The term nephrotomy implies the exposure of the kidney and the making of an incision into its substance.

Indications.—The operation is indicated in the following conditions of the organ:—

(*a*) In certain cases of hydronephrosis and pyonephrosis.
(*b*) In abscess of the kidney.
(*c*) In calculous suppression of urine.
(*d*) In the treatment of certain cases of simple cyst or hydatid cyst of the kidney.

The term exploration of the kidney is sometimes used to indicate the exposure of the organ by a surgical operation, when it is wished to make a digital examination without necessarily making an incision into the renal substance.

Operation.—The instruments necessary for the performance of the operation, and the individual stages of the operation itself, are similar to those described in the preceding operation up to the stage of exposure of the gland. An incision is then made into the diseased portion of the organ, and any fluid collections which may be present are evacuated. Drainage is always requisite after this operation.

Nephrectomy.—The removal of a kidney by the performance of a surgical operation is called nephrectomy. The organ may be removed, either through an incision made in the lumbar region of the diseased side, which does not open the peritoneal cavity, or through a transperitoneal incision in the anterior abdominal wall. The former operation is known as "lumbar nephrectomy," and the latter, "abdominal nephrectomy." The choice between these two operations is a matter of opinion, but it is certainly best to adopt the lumbar method for all cases except those of large solid tumours or polycystic disease of the kidney.

In lumbar nephrectomy, not only is infection of the peritoneum avoided, but also the drainage obtained is far superior to that possible in an operation from in front, although, of course, if the latter procedure be adopted, a second incision may be made in the loin for this purpose. Additional space can always be obtained, if necessary, by prolonging the lumbar wound downwards and forwards immediately above the crest of the ilium, and, however large a hydronephrosis may be, it can always be punctured with a trocar and cannula, and the sac removed through a 5-inch lumbar incision, unless it prove very adherent. The advantages of the abdominal route in those special instances in which it is desirable are :—(*a*) A larger tumour can be removed in this way than is possible through the somewhat limited ilio-costal space ; (*b*) the condition of the renal pedicle can be more satisfactorily investigated, and a ligature placed in closer proximity to the great abdominal trunks than would be safe in the lumbar method ; (*c*) involvement of the lumbar glands, or the presence of secondary visceral growths, will be ascertained if present, and under these circumstances the patient will be spared the necessity of a severe operation, with such a high mortality as that of nephrectomy.

Indications.—Removal of the kidney may be necessary in the following pathological conditions, namely—

(*a*) Certain cases of hydronephrosis, pyonephrosis, and suppurative and cystic affections which are not amenable to treatment by nephrotomy.

(*b*) Some cases of ureteral and renal fistulæ.

(*c*) Cases of unilateral tuberculous disease of the kidney, in which neither the bladder, prostate, nor epididymis are involved.

(*d*) Some cases of severe injury of one kidney.

(*e*) Certain cases of new growth of the kidney, including primary carcinoma and sarcoma, and hypernephroma. Unless it is known that the opposite kidney is not seriously diseased, and is capable of performing its normal functions, in no case would nephrectomy be justifiable. When secondary deposits have formed in other organs, as a result of primary malignant disease of one kidney, removal of the affected organ should not be attempted.

1. Lumbar nephrectomy.—*Special instruments.*—Volkmann's spoon, clamp forceps, and pedicle needle.

Position.—As for nephrolithotomy (see p. 249).

Operation.—The operation may be divided into the following stages, namely :—

(*a*) *Parietal incision.*—The incision is made in the lumbar region, parallel with and about half or two-thirds of an inch below the inferior margin of the last rib. It measures in length from 4 to 5 inches, according to the obesity of the patient and the size of the organ to be removed, commencing in front, and terminating at the external border of the sacro-spinalis (erector spinæ) muscle. The various strata of the abdominal wall are divided as in the operation of " nephrolithotomy," until the posterior aspect of the kidney is exposed. In some cases it will be necessary to prolong the incision downwards and forwards along the crest of the ilium, so as to enlarge the field of operation and facilitate the manipulations of the surgeon.

(*b*) *Enucleation of the kidney.*—Whenever possible the organ should be separated from its surrounding perinephric pad of fatty connective tissue. This may be accomplished in many instances by the fingers, but it occasionally happens when there has been much inflammation—especially in old-standing suppurative cases—that this cannot be done. If the kidney cannot be separated from its surroundings in this manner, it is advisable to open the capsule proper, and then enucleate it. Usually, however, small portions will remain behind, adherent to the fibrous capsule. In very difficult cases, where the exact extent of the renal tissue cannot be made out, the removal may be effected either by cutting with a scalpel or a pair of curved scissors. Sometimes a combination of these methods enables the surgeon to separate the kidney from its surroundings. When the enucleation has been completed, the organ is lifted up in the wound by an assistant, so as to allow the separation and ligature of the pedicle.

(*c*) *Separation and ligature of the pedicle.*—The margins of the parietal wound are held well apart with wide flat metal retractors, whilst the surgeon defines the pedicle and separates it into two parts, an upper containing the blood vessels, and a lower the ureter alone. The portion of the pedicle containing the renal vessels should be carefully separated from the surrounding tissues for a short distance towards the abdominal aorta. This will give more room for the application of the ligature, and there will be less chance of it slipping afterwards. This having been done, a blunt-pointed pedicle needle threaded with chromicised catgut or silk is passed through the centre of the upper portion of the pedicle, and the ligature having been divided the leash of vessels is tied off in two separate bundles, and finally one of the ligatures is carried round the entire vascular stump; these ligatures should be applied an inch or more from the hilum of the kidney. Two pairs of clamp forceps are then placed a short distance apart on the lower half of the pedicle, or ureter.

(*d*) *Removal of the kidney.*—The kidney is lifted up into the parietal wound by an assistant, who takes great care not to exert traction upon the blood vessels; and then the surgeon, with scissors, divides both portions of the pedicle, the upper half, about two-thirds of an inch on the peripheral side of the ligature—that is to say, in most cases at the hilum of the kidney—and the lower half, between the two pairs of clamp forceps. The organ is then removed. When it is difficult to isolate the upper half of the pedicle, owing to extensive inflammatory adhesions, a small button of renal tissue may be left on the distal side of the ligature, so as to prevent any tendency which it might otherwise have to slip. The pedicle is now sponged dry and examined, and if any bleeding points become visible they are picked up with pressure forceps and ligatured with chromicised catgut or silk.

(*e*) *Treatment of the ureter and closure of the external wound.*—When the ureter is apparently healthy, a ligature is applied to it, and it is dropped back into the wound. The entire field of operation is next irrigated, and the parietal incision closed by the insertion of two tiers of sutures, as in nephrolithotomy. If there is any oozing, or there has been recent inflammation, a drainage tube is passed down into the bottom of the wound, and one extremity brought out through an angle of the external incision, which has been left open for the purpose. If the ureter is dilated and filled with pus or tuberculous material, its interior should be well scraped with a small, sharp Volkmann's spoon; and then, if all the diseased tissue has been got rid of, a ligature may be applied as low down as possible, the part above this removed, and the ligatured end dropped back into the wound. When, however, the ureter is extensively diseased, as in some cases of tuberculous disease of the kidney, or in calculous pyonephrosis, it should either be removed at the same time as the kidney or at a later period (see section on "Ureterectomy," p. 273 *et seq.*). The external incision is then closed as before. If all traces of pus cannot be satisfactorily removed, and it is decided not to attempt excision of the ureter, the open end of the latter is brought into the angle of the parietal incision, and fixed there by a few points of suture, the other parts of the incision being closed in the usual manner.

2. Abdominal nephrectomy.—*Instruments.*—The instruments are the same as those required for the "lumbar" operation.

Position.—The patient is placed in the dorsal position on the operating table, the surgeon stands on the affected side, the chief assistant opposite to him, and a second assistant at his right hand.

Operation.—The stages of the operation are—

(*a*) *Abdominal incision.*—An incision from 4 to 6 inches in length, according to the size of the diseased kidney and the thickness of the abdominal walls, is made in the linea semilunaris of the affected side, the centre of the incision being at the level of the umbilicus. This is deepened until the peritoneal cavity has been opened for the entire length of the incision. The hand of the surgeon is then introduced through the aperture, and the size and the connections of the diseased organ made out, and, in addition, the kidney of the opposite side is examined by passing the hand over to that side. If the patient is fat, considerable difficulty may be experienced in distinguishing the healthy kidney, owing to the large amount of perinephric fat which surrounds it. If it is found advisable and possible to remove the diseased kidney, and that on the opposite side is present and healthy, the operation is proceeded with.

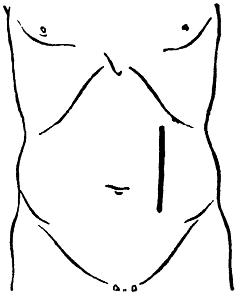

FIG. 191.—Abdominal nephrectomy. Position of external incision.

(*b*) *Exposure of the kidney.*—The small intestines and omentum are pushed over towards the opposite side of the abdomen, and held out of the way by the insertion of one or more abdominal pads. The margins of the external wound are held apart with retractors, and the lateral aspect of the colon on the diseased side defined. The parietal peritoneum, on the lateral side of the colon and 1 inch beyond it, is divided, or, better, torn with the fingers until an aperture 2 or 3 inches in length has been made. By tearing the tissues with the fingers the peritoneum on the anterior aspect of the posterior abdominal wall, together with the colon, is lifted up and separated from the anterior surface of the kidney and its blood vessels. A number of small blood vessels may require ligature during this stage.

(*c*) *Separation and ligature of the pedicle.*—When the anterior aspect of the kidney and its pedicle has been exposed, the vessels are separated as far as possible from the adjacent tissues with the finger, and, having been transfixed with a blunt aneurysm needle, they are securely tied off in two separate bundles 1 inch or more from the hilum of the kidney. The ureter is next either seized with clamp forceps in two places or ligatured.

(*d*) *Removal of the kidney.*—The ureter is severed on the kidney side of the clamp, the blood vessels are divided, and then any connections between the kidney and the surrounding tissues are broken down with the finger. The organ can now be lifted out of the wound and removed. If it is doubtful whether the ligature on the blood vessels will hold, a second one ought to be applied a short distance nearer the aorta, taking care to avoid the inferior vena cava on the right side. All bleeding points in the field of operation are picked up with pressure forceps, and ligatured. If the ureter is healthy, a ligature is applied to it and it is dropped back into the abdomen ; but if it is dilated and filled with pus or tuberculous material, it is best either to remove it or to scrape away as much of the purulent matter as possible, and then to make a small incision in the lumbar region, and bring it out through this opening, the margins of its open end being fixed by suture to the external wound.

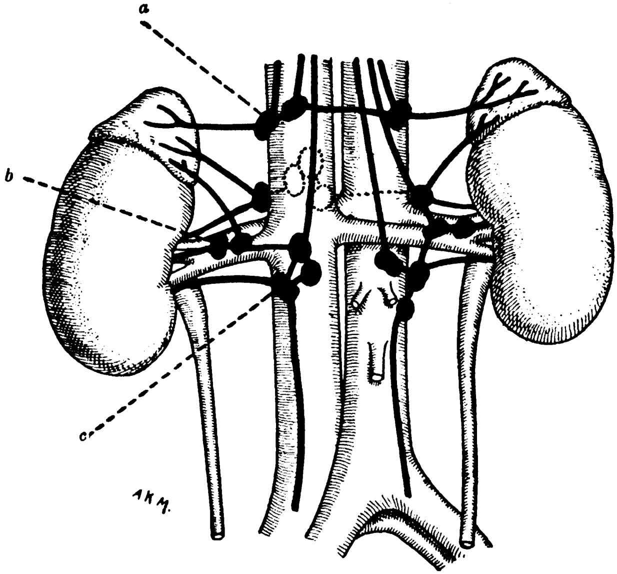

FIG. 192.—Position of lymph glands receiving lymph vessels from kidney and suprarenal.

a. Lymph glands on inferior vena cava receiving lymph vessels from suprarenal.
b. Renal vessels.
c. Lymph glands on inferior vena cava receiving lymph vessels from pelvis of kidney.

(*e*) *Treatment of the peritoneum, and closure of the external wound.*—The space from which the kidney has been taken is thoroughly sponged out and irrigated with hot salt solution, so as to remove all blood-clots, etc., and render evident any bleeding vessels which may have escaped ligature. When this has been done, the peritoneum and the intestines are allowed to fall back into their former positions. The wound in the peritoneum on the lateral side of the colon must be sutured, and if there is considerable oozing of blood from the field of operation a second incision should be made in the loin, and through it a drainage tube inserted. The external wound is closed in the usual manner.

Nephrorrhaphy, or Nephropexy.—The operation which has for its object the fixation of an abnormally movable kidney to the posterior abdominal wall is called nephrorrhaphy, or nephropexy, the former term being more commonly used.

Indications.—The cases in which operation is advisable may be divided into four classes :—

(*a*) All cases of movable kidney showing acute exacerbations of anterior renal pain, often accompanied by vomiting and occasionally by hæmaturia.

(*b*) Cases of movable kidney showing evidence of pathological changes in the kidney, namely, hydronephrosis, transient albuminuria, casts in the urine, or increased frequency of micturition.

(*c*) Cases in which the movable kidney is mechanically causing changes in other viscera, *e.g.* stomach or duodenum.

(*d*) Cases of movable kidney with severe aching in the lumbar region, in which an efficient truss has failed to relieve the symptoms.

The following conditions contra-indicate operation :—

1. Movable kidney associated with Glenard's disease.
2. Marked prolapse of the genital organs in the female.
3. A pronounced type of neurosis in the patient.

Special instruments.—As for nephrotomy, and in addition a fully curved round-bodied needle.

Position.—The positions of the patient, surgeon, and assistants are the same as in lumbar nephrectomy.

Operation.—The stages of the operation are—

(*a*) *Parietal incision.*—The incision, which should be 4 or more inches in length, depending on the fatness of the patient, commences above in the posterior renal or sub-costal angle at the outer border of the sacro-spinalis (erector spinæ), and passes downwards and slightly outwards towards the crest of the ilium. The upper angle of the incision should be about ½ inch below the lower margin of the last rib. It should be either carried through the almost vertically running fibres of the latissimus dorsi and external oblique, until the transverse fibres of the lumbar origin of the internal oblique are exposed, or if possible the different muscular strata are divided parallel with their fibres. Two lateral flaps are then made of all the tissues so far divided by a few lateral sweeps of the knife through the loose areolar tissue separating the muscular layers, until the surface of the internal oblique is bared for an extent of about ¾ inch on each side of the incision. The internal oblique and tranversus are then divided in the line of the original incision. It is not always advisable to split the muscles in the direction of their fibres, as sometimes a satisfactory exposure cannot be obtained by this means, and the risk of a lumbar hernia, occurring in an aseptic case, is so small that, for practical purposes, it can be neglected. All bleeding points are now picked up and ligatured with fine silk, and the deeper part of the wound is sponged out and exposed by the insertion of a large pair of retractors.

(*b*) *Exposure of the kidney, removal of fat and connective tissue from its posterior aspect, and separation of a portion of its fibrous capsule.*—In these cases a large amount of perinephric fat is the exception, and consequently the post-renal fascia can be picked up with dissecting forceps and incised, and then the fatty capsule broken down with the finger until the postero-lateral surface of the kidney comes into view. If the kidney is very movable some difficulty may occur at first in localising it, and firm, steady pressure from the front in an upward and backward direction by the assistant's clenched fist will greatly expedite matters. Having found the kidney, it is wise, before proceeding further, to separate, ligature, and remove all fat and loose connective tissue that will be likely to intervene between the posterior aspect of the kidney in its new position and the lumbar parietes ; for not only will this prevent proper fixation, but also, as this tissue has a poor blood supply, its vitality will be impaired by the tearing process, and in consequence the presence of tags will favour the occurrence of suppuration. Owing to the lengthened renal pedicle, no difficulty, other than that occasioned by the free mobility of the organ, will be met with in bringing the kidney out on to the loin ; but, before doing this, some estimate of the space in the upper part of the vertebral recess at the disposal of the surgeon should be formed. The object to be attained is to place the kidney at its normal level in the loin, or, failing that, to fix it as high as space will allow.

The process of partial decapsulation is effected by an " I "-shaped incision through the tunica propria, the perpendicular portion of the " I " being situated well towards the outer part of the posterior surface of the kidney (Fig. 193). The two lateral flaps, so marked out, separate quite readily, and should be turned outwards and laid flat upon the surface of the kidney. The denuded area should have a long diameter not less than two-thirds of the long axis of the kidney, and its breadth should be 2 inches or slightly less.

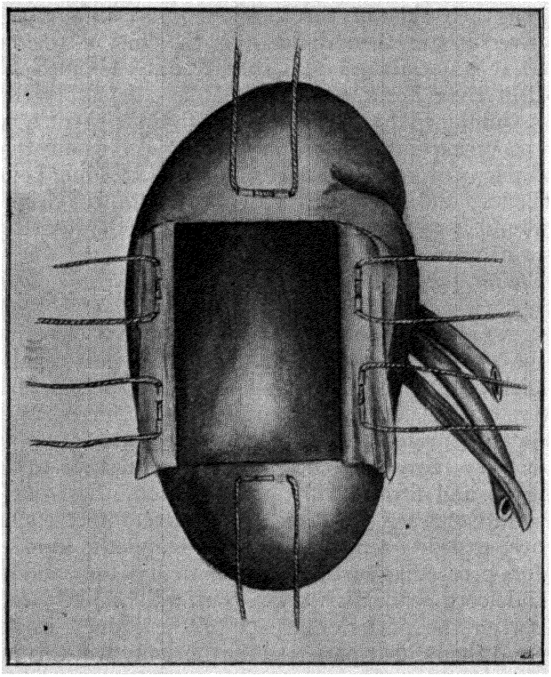

FIG. 193.—Nephrorrhaphy. Method of insertion of " fixation " sutures.

(*c*) *Fixation of the kidney to the tissues in lumbar region.*—Sutures of No. 2 silk are now passed by means of a large curved needle ; six, as a rule, are sufficient, and these should be arranged as shown in the accompanying figure. The two lateral sutures on each side take up, by means of an in-and-out movement of the needle, two layers of capsule, no portion of the renal cortex being included in their grasp. The two polar sutures take up only one layer of capsule, and are situated respectively immediately above and below the decapsulated area. The kidney is now replaced in the renal recess, and the sutures are passed through the lumbar parietes, taking up the internal oblique and transversalis muscles only. The polar sutures traverse both edges of the muscular layer, but the lateral sutures are passed ¾ to 1 inch away from the edge of the incision of their own side. Each end of a lateral suture is passed separately, so that, when the ends are tied together, the suture may include a sufficient piece of the muscular layer to ensure a firm grip.

(*d*) *Closure of external wound.*—None of these renal sutures are tied until the cut margins of the internal oblique and transversus have been brought together by interrupted sutures of fine silk. When this has been done, the kidney is pressed firmly up into the loin from in front by the assistant's hand, and the renal sutures gradually tightened. It is obvious that the final position of the kidney depends upon the relative level of the decapsulated area on the posterior renal surface, and the level at which the uppermost suture passes through the edges of the incision. The superficial muscular layer is approximated by another row of interrupted sutures of fine silk, and then the skin incision is closed, without drainage, by sutures of salmon gut.

OPERATIONS UPON THE URETERS

Anatomical considerations.—The ureter is a hollow muscular tube, about 11 inches in length, which commences at the pelvis of the kidney, and passes downwards and medially to end in the bladder at the postero-lateral angle of the trigone. Throughout its entire course it lies in the extra-peritoneal tissue, and where it leaves the lateral pelvic wall to enter the base of the bladder it is surrounded by a very strong band of fibrous tissue, which helps to keep the trigone stationary during the varying degrees of distension of the bladder. The ureter may be divided into three portions : (*a*) abdominal ; (*b*) pelvic ; and (*c*) vesical.

(*a*) The abdominal portion, 5 to 6 inches in length, passes downwards and medially to enter the cavity of the small pelvis by crossing either the termination of the common iliac or the beginning of the external iliac artery ; on the right side it passes behind the termination of the ileum, and on the left is concealed from view by the pelvic colon. Throughout its entire course it lies upon the psoas magnus muscle, crosses the genito-femoral (genito-crural) nerve, and is crossed by the spermatic or ovarian artery.

(*b*) The pelvic part, 4 to 5 inches in length, passes downwards and forwards round the lateral wall of the pelvis, immediately in front of the hypogastric artery (internal iliac); it crosses the obturator vessels and nerve, and in the female forms the posterior boundary of the fossa ovarica. In the remainder of its course its relations differ in the two sexes. In the male, it now passes forwards and medially along the upper border of the vesiculæ seminales, has the ductus (vas) deferens separating it from the bladder, and is surrounded by the inferior vesical plexus of veins. In the female, it enters the base of the broad ligament, passes behind the uterine artery in the transverse part of its course, and then turns forwards below it to reach the base of the bladder; where it lies in relation with the artery it is ½ inch from the side of the cervix, and below this is in direct relation to the lateral vaginal fornix.

(*c*) The vesical portion, ¾ inch in length, pierces the musculature of the bladder base very obliquely, and is usually seen opening by means of a transverse slit on the summit of the outer portion of the prominent bar of muscle, which bounds the trigone behind.

Varieties of operation.—From a surgical point of view, the ureter may be exposed by an operation either in the abdominal or pelvic portion of its course, and it may be approached either through the peritoneum or outside this membrane. The former operations are called " trans-peritoneal " and the latter " extra-peritoneal." As regards regions, the ureter may be attacked from the loin—lumbar operation; from the iliac region—iliac operation; from within the bladder—vesical operation; and through the antero-lateral abdominal wall, by an incision through the corresponding linea semilunaris, or transversely by incision illustrated in Fig. 197—abdominal operation. By a combination of the lumbar and iliac operations, almost the entire course of the ureter may be exposed.

Other methods have been suggested and occasionally practised, such as rectal, sacral, perineal, and vaginal. For a discussion of these, the student is referred to a larger treatise. The operations here mentioned will be found to meet nearly all practical requirements.

The different methods of exposing the ureter will now be described, and afterwards the various surgical procedures which can be performed, as well as the main indications for them.

Lumbar operation.—*Position.*—The patient is placed lying on the sound side with a hard pillow or sandbag underneath the loin. The surgeon stands behind the patient, and his assistant on the opposite side.

Operation.—An oblique incision 5 inches long is made, commencing 1 inch above the anterior superior spine of the ilium, and extending upwards and backwards to a point 1 inch below the lower margin of the last rib and over the lateral margin of the sacro-spinalis (erector spinæ) muscle (about 2 inches from the spinous processes of the vertebræ). The skin, fascia, and muscular strata are divided as in exposure of the kidney, and the post-nephric fascia laid bare. This is carefully incised for the entire length of the incision, and then the perinephric fatty tissue in the upper portion of the wound broken down with the finger or dissecting forceps, until the lower part of the kidney is visible. The pelvis of the kidney is then defined on the medial side, and the ureter traced downwards and inwards as far as the brim of the pelvis, where it crosses the common iliac artery. Care must be taken to avoid opening the peritoneum in exposing the abdominal course of the ureter. This can generally be done by keeping close to the lateral margin of the quadratus lumborum muscle. In order to obtain a good exposure of the deeper structures, after division of the muscular and fascial strata, the margins of the wound should be held widely apart by large abdominal retractors (Fig. 189). If further exposure of the ureter be required, the incision should be prolonged forwards parallel with the inguinal ligament (Poupart's).

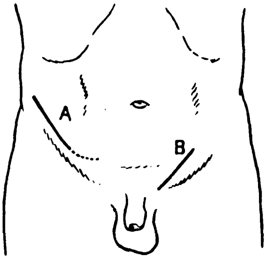

Fig. 194.—Exposure of ureter by iliac method.

A. Incision in iliac operation.
B. Incision in inguinal operation.

Iliac operation.—*Position.*—The patient is placed in the dorsal position, the surgeon stands on the affected side of the patient, and the assistant on the opposite side.

Operation.—An incision 4 to 5 inches long is made, commencing at a point ¾ inch above the inguinal ligament (Poupart's), a short distance to the lateral side of the lateral vertical plane, and extending upwards and backwards parallel with the inguinal ligament (Poupart's) and the iliac crest, to a point the same distance above the iliac crest and 2 inches behind the anterior superior spine of the ilium. This incision passes through skin, superficial and deep fasciæ. The external oblique, internal oblique, and transversus (transversalis, O.T.) abdominis are split in the direction of their fibres, the transversalis fascia incised, and the extra-peritoneal tissue exposed. Care must be taken not to injure the inferior (deep) epigastric artery in the medial angle of the incision. If it is exposed it should be pulled inwards with a retractor. With the fingers the peritoneum is separated from the anterior aspect of the fascia in the iliac fossa, until the external iliac artery is laid bare. This is then followed upwards and medially until the ureter is found as it crosses the brim of the pelvis. The ureter frequently remains adherent to the stripped peritoneum and may be overlooked. The medial margin of the wound is next strongly retracted, the peritoneum peeled from the lateral wall of the pelvis, and the ureter traced downwards, forwards, and medially until it reaches the base of the bladder. The terminal part of the ureter is recognised by the appearance of the ductus (vas) deferens and the vesicula seminalis in the medial part of the wound, and the bladder by the reddish strands of muscular fibres. Gentle traction on the first exposed pelvic portion of the ureter assists in fully exposing the deeper part at its junction with the bladder. Considerable hæmorrhage may be met with in exposing this terminal portion, owing to injuries to the veins of the inferior vesical plexus.

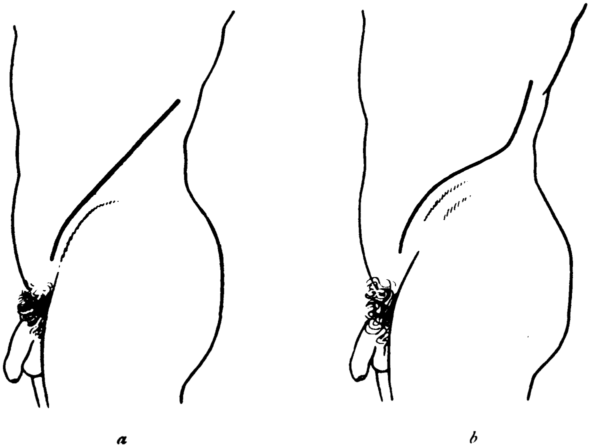

FIG. 195.—Exposure of entire course of ureter by an ilio-lumbar incision.

a. Oblique incision. | *b.* Curved incision.

In both of these operations the ureter can generally be readily recognised, especially when it is enlarged by an impacted calculus, or dilated owing to obstruction in some part of its course. In order to expose the entire ureter, the above two incisions may be combined, as in Fig. 195.

Trans-peritoneal operation.—*Position.*—The position of the patient, surgeon, and assistants is the same as in the previous operation. The parietal incision varies according to whether it is desired to expose the abdominal or the pelvic portions of the ureter. It is best made about a half to three-quarters of an inch to one side of the middle line, in the position shown in Fig. 196, for the pelvic part of the tube; and through the linea semilunaris when it is wished to deal with the abdominal portion.

For exposure of abdominal part.—An incision 4 inches long is made in the corresponding linea semilunaris, commencing 1 inch above the umbilicus, and extending 3 inches below it. The abdominal walls are incised, and the peritoneal cavity opened, as in the operation for abdominal nephrectomy. The position of the portion of the ureter it is wished to expose being determined upon, an incision about 2 inches long is made through the parietal peritoneum on the posterior abdominal wall and well to the outer side of the ureter. The ureter having been defined, it is dealt with according to one of the methods described in the succeeding sections. In order to obtain a good view of the ureter, the wound must be widely retracted, and the intestines packed well over to the opposite side of the abdomen by means of a large abdominal pad.

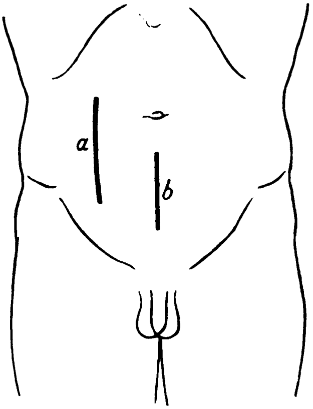

FIG. 196.—Incisions to expose ureter by "trans-peritoneal method."

a. For abdominal part.
b. For pelvic part.

For exposure of pelvic part.—An incision 3½ to 4 inches long is made half an inch to one side of the middle line. The different strata of the abdominal wall are divided, and the peritoneal cavity opened. The coils of intestine and the omentum are pushed well upwards out of the way, and the position of the ureter within the pelvis determined. This can readily be done if it be remembered that the ureter in this part of its course is lying immediately in front of the hypogastric artery. An incision 2 inches long is then made through the parietal peritoneum of the pelvis parallel with the ureter, and a little above it. The peritoneum is separated, and the course of the ureter laid bare. Care must be taken during this procedure not to allow the assistant to retract the ureter along with the peritoneum. Very deep and wide abdominal retractors, of the shape shown in Fig. 189, are necessary for the performance of this operation.

Abdominal extra-peritoneal operation. — The patient is placed in the raised pelvic position, and an incision—usually about 4 inches long—is made not quite transversely in the position illustrated in Fig. 197. The different strata of the anterior abdominal wall are then divided or separated. First the skin, superficial fascia, deep fascia, and external oblique muscle are cut through and retracted. Next the rectus abdominis is pulled inwards and the posterior portion of the rectus sheath divided parallel with its fibres, and the incision prolonged outwards or laterally so as to divide the internal oblique and transversalis muscles in the outer portion of the field of operation. These muscles having been retracted in an upward and downward direction, the fascia transversalis is cut through and

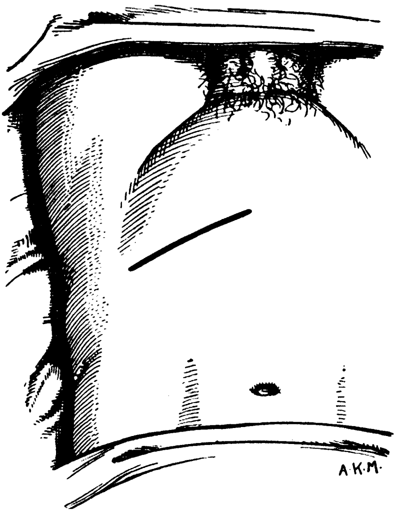

FIG. 197.—Incision for exposure of left ureter—pelvic portion— by extra-peritoneal route. (The patient has been placed in the raised pelvic position, and the view is as seen by the operator standing on the left side.)

the extra-peritoneal fatty tissue exposed. Next the parietal peritoneum is pushed inwards together with the adjacent coils of intestine, and the ureter defined as it passes over the pelvic brim. This is traced downwards until an enlarged portion is

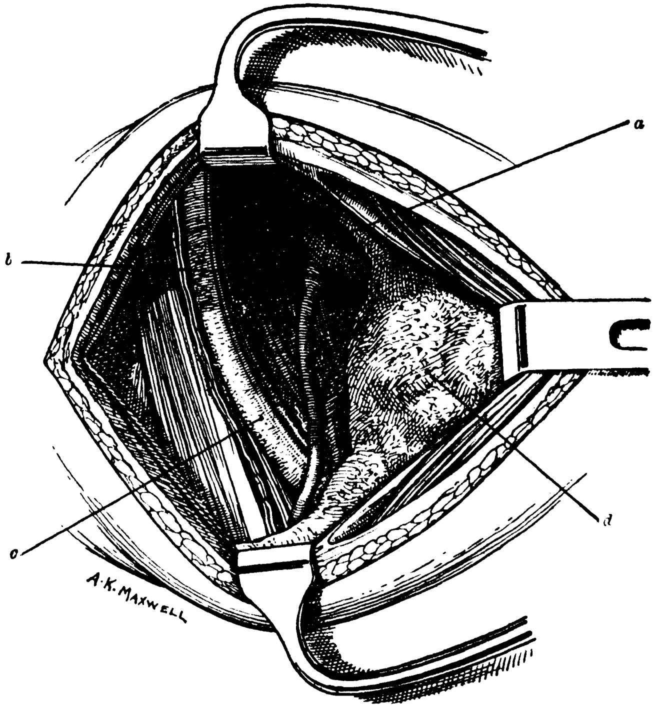

FIG. 198.—Position of structures exposed in extra-peritoneal method of removal of calculus from pelvic portion of ureter.

a. Urinary bladder.
b. Lower part of ureter distended and containing a calculus.
c. Common iliac artery.
d. Parietal peritoneum.

seen which contains the impacted calculus. The special retractors depicted in Fig. 189 are especially useful on obese patients in exposure of the ureter. Fig 198 shows a calculus impacted in the lower portion of the ureter close to the urinary bladder. When the position of the calculus has been determined, an incision vertical in direction to the long axis of the ureter should be made, the lumen of the ureter opened, and then the calculus extracted either with long-handled calculus forceps or a long calculus scoop. Next the incision in the ureter is closed with a few points of fine catgut suture and a rubber drainage tube of small calibre passed down to the bottom of the wound. Finally the layers of the abdominal wall are sutured tier by tier, by the insertion of interrupted catgut sutures. The skin is closed with salmon-gut sutures.

When a urinary calculus is arrested in the pelvic portion of the ureter, this is an operation to be strongly commended. It is safe, and as the peritoneal cavity is not opened there is practically no risk of peritonitis.

Comparison of the extra-peritoneal and intra- or trans-peritoneal methods, and general indications as to choice of operation.—The *intra-* or *trans-peritoneal* method is the only one which can be adopted where it is desired to establish an anastomosis of the ureter with either the bladder or a portion of the alimentary canal; otherwise, in all cases of calculi, strictures, valvular formations of the mucous membrane, and when excision of the whole or part of the ureter is necessary, one of the extra-peritoneal methods should be made use of. A considerable number of patients, in whom operations upon the ureter are requisite, have a septic condition of the urine, or there may be ulceration of the walls of the ureter; in all these, *trans-peritoneal* operations are almost invariably followed by the development of peritonitis, either by contamination of the peritoneum at the time of operation, or by extension of septic urine to it afterwards along the course of the incision. All cases in which it is necessary to incise the wall of the ureter are very liable to have an escape of urine for a short time along the line of incision, and if this has been performed by the *trans-peritoneal* method, it usually happens that the escaped urine sooner or later enters the peritoneal cavity and gives rise to serious complications.

In my opinion, the extra-peritoneal operations, in the majority of instances, give quite as good if not a better view of the ureter; the ureteral manipulations can be carried out with as great ease; and in every case satisfactory drainage can be easily and effectively established. These are the reasons for so strongly advocating the adoption of extra-peritoneal operations, with the exception of those cases where the establishment of an anastomosis is necessary.

Vesical operation.—The interior of the bladder is exposed by performing a preliminary " suprapubic cystotomy," according to the method given on page 289 *et seq.*, and then the opening of the ureter into the bladder on the affected side is incised, and sufficiently enlarged to carry out whatever may be necessary on the lower part of the ureter. This operation is of especial value in cases of impaction of a urinary calculus in the terminal portion of the ureter, and in constrictions of the ureteral opening due to cicatrisation following a previous ulceration. When these operations are performed, the patient should always be placed in the inclined or " Trendelenburg " position.

Ureterotomy.—This operation comprises the making of an incision through the wall of the ureter, and is performed in the majority of instances for removal of urinary calculi impacted in the lumen of the ureter (uretero-lithotomy), occasionally for removal of a valve of mucous membrane which interferes with the ordinary permeability of the canal of the ureter, and also as the first part of the operation of " ureteroplasty " (p. 273, *q.v.*).

Exposure of the bladder wall in the region of the ureteric opening can be best exposed by using a retractor speculum of the form shown in Fig. 199.

Position.—The position of the patient varies according to the part of the ureter it is wished to expose. When the lumbar portion is sought, the patient is placed in the semi-prone position ; and when the pelvic or vesical parts are the seat of disease, he is placed in the dorsal position, with the pelvis raised.

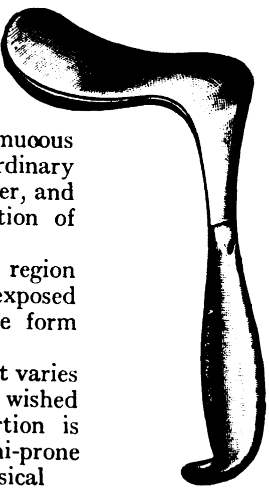

Fig. 199.—Retractor speculum for exposing portions of internal aspect of bladder.

Operation. — The operation can be carried out in the following stages :—

(*a*) *Exposure of the ureter.*—The ureter is exposed by incising the abdominal walls, according to one of the methods already described.

(*b*) *Separation and fixation of the portion of the ureter it is wished to deal with.*—When the seat of impaction of the urinary calculus, or the locality of some other pathological condition, has been determined, the ureter is separated by careful dissection from the peritoneum in front and the fascia behind, for a distance of about 3 inches, and then this portion is brought towards the parietal wound and held in position by an assistant. Usually this is quite easy, as the ureter is surrounded by loose connective tissue containing a variable amount of fat; but when inflammation has occurred, considerable difficulty may be experienced in effecting the separation.

(*c*) *Incision of ureter.*—When a calculus is immovably impacted within the canal, a longitudinal incision is made on the postero-lateral aspect of the ureter, opposite the position of the calculus, and sufficiently long to permit of easy extraction without laceration of the walls. Extraction is best carried out by the aid of long-handled, narrow-bladed calculus forceps. If the calculus can be moved upwards, an incision of sufficient length is made through the postero-lateral wall of the dilated ureter, about an inch or a little more above the seat of arrest of the stone. The calculus having been removed, the course of the ureter is investigated with a bougie, in order to detect a second calculus if present, and also to determine the permeability or otherwise of the canal. When the object of operation is the treatment of a valve of mucous membrane, the position of this valve is first determined, and then the postero-lateral wall of the ureter incised in a vertical direction, parallel with the long axis of the tube, and immediately on the kidney side of the lesion, for an inch or a little more. The projecting fold of mucous membrane is then cut away.

(*d*) *Treatment of the wound in the ureter.*—Whenever the parts operated upon are not the seat of septic inflammation or suppuration, and the ureteral walls have not been lacerated, the incision in the ureter should be carefully closed by the insertion of a series of fine sutures of chromicised catgut. If, however, the area of operation is septic, as it is certain to be if the urine is infected, or when the ureteral walls have been lacerated, it is better not to attempt to close the opening, but to establish free drainage through a convenient part of the parietal wound.

(*e*) *Closure of parietal wound.*—If the opening in the ureter has been closed by sutures, a roll of gauze or a small drainage tube should be passed down to the seat of the sutures, and the other extremity brought out through the nearest part of the external wound. The other portions of this wound are then closed by tiers of catgut sutures.

When the opening in the ureter has been left partially or completely unsutured, a large rubber drainage tube should be passed down to the ureteral opening and brought out at a convenient portion of the parietal wound. A sufficient portion of the latter is left open so as to allow very free drainage, and the remainder closed by careful suturing.

If a calculus is impacted immediately above the opening of the ureter into the bladder, or a fibrous constriction exists at this opening, a suprapubic cystotomy is first performed (p. 289, *q.v.*) in order to expose the part of the ureter affected. Next, the opening of the ureter on the affected side is brought into view and incised in an upward and outward direction. In the case of an impacted calculus, this is removed with suitable forceps through the opening thus made. The vesical and ureteral wound is then sutured, care being taken to leave a good canal for the subsequent passage of urine. If the pathological condition is a stricture or stenosis of the ureteral opening into the bladder, the opening is first enlarged by incision, as above, and then the mucous membrane of the adjacent portion of the bladder is dissected up for a short distance and if possible sutured to the margins of the enlarged opening. This procedure prevents subsequent contraction of the orifice.

Ureteroplasty.—This operation consists in restoring the lumen of a constricted ureter to its normal size by the performance of a plastic procedure.

Indications.—Stricture and stenosis of the ureter dependent either upon some previous ulceration of its walls, or due to injury.

Operation.—The ureter is exposed by one of the methods already described, and the affected portion separated from its connective tissue and peritoneal surroundings. A vertical incision is then made through the wall of the ureter, extending the entire length of the stenosed part, and also for a short distance above and below it. Next, the margins of this incision are separated, and then approximated by traction, until they come together in a direction at right angles to the long axis of the tube. The two extremities of the original incision in the wall of the ureter are now fixed together by the insertion of a fine chromicised catgut suture, and subsequently the other parts of the incision in a like manner. The details of the suturing are exactly similar to those described in connection with " pyloroplasty " (p. 96, *q.v.*).

When the operation upon the ureter has been completed, a small gauze drain is passed down to the sutured area, and the end brought out through an angle of the parietal wound. The other portions of this wound are then closed by insertion of tiers of sutures.

Ureterectomy.—By the term ureterectomy is understood removal of either the whole or part of the ureter. It may be carried out at the same time as removal of the kidney, or at a later period. The term " resection of the ureter " is generally given to the operation which comprises excision of a segment of the ureter, and subsequent anastomosis, either of the two cut ends, or, when it is the distal portion of the tube which has been removed, of the proximal end with the bladder or a part of the intestinal canal.

Indications.—(*a*) Tuberculous disease of the ureter, when the kidney of the corresponding side is affected, and the opposite kidney and bladder are healthy.

(*b*) Chronic ureteral fistula, which cannot be cured by other means.

(*c*) Chronic inflammation and suppuration following calculous disease in connection with the ureter, or, in occasional cases, chronic ureteritis, the result of extension of the suppurative process from the kidney or bladder.

(*d*) Malignant growths of the ureter when they have not too extensively involved the adjacent tissues, and are not accompanied by the formation of secondary growths.

All operations for removal of the ureter ought to be carried out by the extra-peritoneal method, except in those cases in which it is done as part of an operation for removing a malignant tumour of the bladder. In this latter class suprapubic cystotomy is first performed, and in removal of the bladder growth the peritoneal cavity is usually of necessity opened.

Position.—The patient is placed in the semi-prone position lying upon the sound side; the surgeon stands on the affected side, and his assistant opposite to him. It is advisable to have a second assistant, on account of the large wound requiring considerable retraction.

Operation.—Removal of the ureter may be divided into the following stages:—

(*a*) *Parietal incision and exposure of the ureter.*—The ilio-inguinal incision is first made as in Fig. 194, later it may be continued backwards or forwards if this is found requisite, and the course of the ureter exposed.

(*b*) *Separation and removal of the ureter.*—The ureter having been identified, it is separated from the overlying peritoneum and surrounding connective tissue by careful dissection, opening of the peritoneum at any point being especially avoided. When the kidney is to be removed at the same time, this part of the operation is proceeded with first, and is completed by clamping the upper portion of the ureter in two places and dividing between. The lower part of the ureter is then separated down to a point as near its junction with the bladder as possible, a ligature is applied close to the bladder, a clamp placed ½ inch on the proximal side of this, and the ureter severed close to the ligature, and removed. When the lumen of the ureter contains purulent matter, the region of the bladder should be carefully packed off with gauze, which will absorb any fluid exudation, and so avoid contamination of the pelvic portion of the field of operation with septic material. Next, the mucous membrane of the stump of the ureter is cauterised, either with liquefied carbolic acid (90 per cent.) or with the actual cautery, and the fibrous and muscular coats sewn over it with two or three points of silk suture, introduced by Lembert's method. Whenever the mucous membrane of the stump is thickened and infiltrated, all softened tissue should be scraped away with a small Volkmann's spoon before cauterisation.

(*c*) *Treatment of the wound.*—The entire wound should be thoroughly irrigated with salt solution, and then two rubber drainage tubes inserted. One of these is placed in the lumbar portion of the wound, and the other in the pelvic part. The portions of the parietal wound between, above, and below the places of exit of the drainage tubes are finally closed by sutures.

The operation of simultaneous removal of the kidney and ureter is known as " nephro-ureterectomy." It should only be done in those cases where the general condition of the patient is sufficiently good to allow of so severe an operation. Occasionally it will be found advisable to remove the ureter at a subsequent period. This is usually called " *secondary ureterectomy.*"

Resection of the ureter.—This operation is indicated in—

(*a*) Cases of hard fibrous stricture of the ureter which cannot be treated by ureteroplasty.

(*b*) Injuries of a small segment of the ureter, when associated with severe laceration of the ureteral wall.

(*c*) Involvement of a small segment of the ureter in a malignant growth, which can be removed by operation.

Operation.—The stenosed portion of the ureter, or the part involved in a malignant growth, is exposed by one of the methods already described, then the diseased portion is excised by cutting across the tube transversely in two places, and taking away the part thus separated. When this has been done, one of the methods of " uretero-anastomosis " is carried out in order to complete the operation, and so establish the patency and continuity of the ureteral canal (p. 276 *et seq.*).

Ureteral anastomosis.—An anastomosis may be established between an open end of a ureter and the distal portion of the same ureter, between it and the urinary bladder, or between it and a segment of the alimentary canal. These are called respectively, "uretero-ureteral anastomosis," "uretero-vesical anastomosis," and "uretero-intestinal anastomosis." The first two operations are those usually practised, uretero-intestinal anastomosis having been found to be almost invariably followed by septic conditions of the ureter and kidney, which ultimately prove fatal.

Indications for "ureteral anastomosis" :—

(*a*) When resection of a portion of the ureter has been performed for stenosis, ulceration, local destruction, or malignant growths.

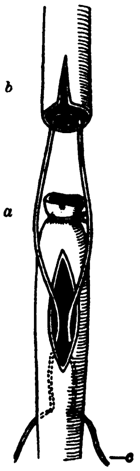

Fig. 200.—Uretero-ureteral anastomosis (Van Hook's lateral method).
a. Distal part of ureter.
b. Proximal part of ureter.
c. Suture.

(*b*) After accidental or intentional division, during the performance of abdominal or pelvic operations.

(*c*) After injuries which have caused division of the ureter. These may be either intra- or extra-peritoneal, and perforating or non-perforating. Before deciding which variety of ureteral anastomosis is most advisable, and whether it shall be carried out by an extra-peritoneal, or an intra-or trans-peritoneal operation, every individual case must be carefully considered, and the advantages or disadvantages of the proposed operation discussed. As a general rule, it may be stated that most cases which require ureteral anastomosis can be most conveniently operated upon by the trans-peritoneal method, and that uretero-ureteral anastomosis should only be made use of when the course (and not the lower extremity) of the ureter is the seat of the lesion; uretero-vesical anastomosis must be practised when the lower portion of the ureter is involved.

Uretero-ureteral anastomosis.—This form of anastomosis can be carried out either by suturing together directly (transversely or obliquely) the cut ends of a divided ureter, by invaginating the upper end into the lower, or by closing the open end of the distal segment and implanting the end of the proximal segment into the side of the first part of the distal. When the ureter above its lower extremity has been the seat of some disease or injury which has necessitated ureteral anastomosis, according to the records of published cases, the lateral operation appears to have been followed by the best results. The actual establishment of uretero-ureteral anastomosis is effected by the following procedures :—

(*a*) A circular ligature is placed around the distal segment about ¼ inch from the cut extremity (Fig. 200, *a*).

(*b*) With a pair of fine-pointed scissors a longitudinal incision, twice the length of the diameter of the ureter, is made in the wall of the distal portion of the ureter, ¼ inch below the circular ligature (Fig. 200, *a*), and an incision vertical in direction is also made in the free end of the proximal segment for a distance of ¼ inch (Fig. 200, *b*). This second incision is said to ensure patency of the canal and prevent development of a stricture.

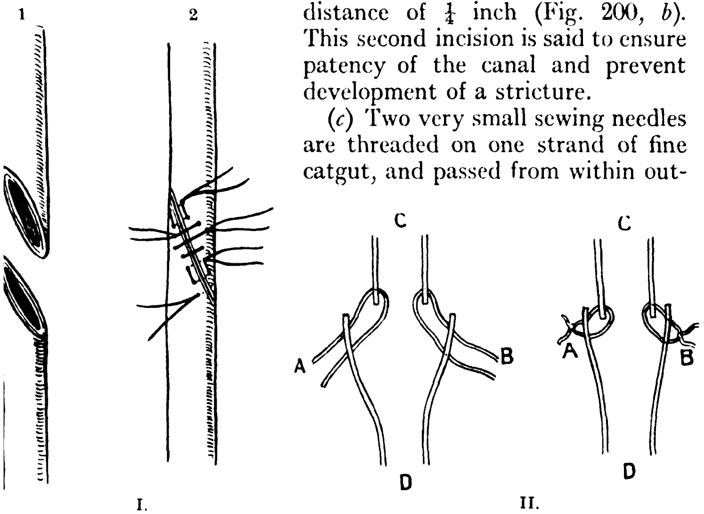

FIG. 201.—Uretero-ureteral anastomosis.

I. Bovée's *oblique* method—(1) Ends of ureter prepared and (2) sutured.
II. Poggi's *end-in-end* method.
A. and B. Sutures. | C. Proximal part of divided ureter.
D. Distal part of divided ureter.

(*c*) Two very small sewing needles are threaded on one strand of fine catgut, and passed from within outwards, through the wall of the proximal end of the ureter ⅛ inch from the free end, the needles being about ⅛ inch apart. These needles are carried through the aperture or slit in the side of the distal part of the ureter, down the tube for ½ inch, and then pushed through the wall of the duct side by side.

(*d*) Traction is now made on the catgut loop which passes through the wall of the ureter, so as to draw the upper or proximal segment of the ureter into the lumen of the lower or distal portion. The two ends of the loop are tied firmly together, and one or two fine sutures inserted to fix the fibrous and muscular coats of the ureter at the margin of the lateral aperture. The peritoneum is then replaced and sutured in the trans-peritoneal operations, and the operation completed in the usual manner.

When lateral anastomosis cannot be performed, on account of the small amount of ureter which is available, the two ends must be joined together directly by sutures either by the transverse or the oblique method, according to the manner of section. Fig. 201, I. and II., shows the different stages of these proceedings.

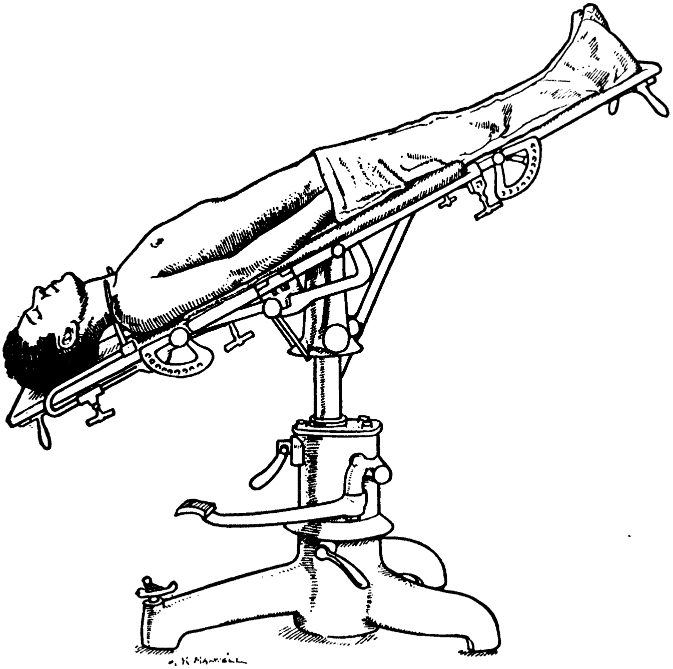

Fig. 202.—Position of patient and operating table for operations on urinary bladder.

Uretero-vesical anastomosis or uretero-cystostomy.—In the operation of uretero-vesical anastomosis a new seat of communication at a higher level than usual is established between the lumen of the lower portion of the ureter and the lumen of the urinary bladder.

Indications.—(*a*) Uretero-vaginal or uretero-uterine fistula is the most common clinical condition which demands the performance of this operation, and is to be recommended in preference to removal of the kidney of the affected side or of anastomosis between the ureter and a portion of the alimentary canal, such as the rectum. The cause of the fistula is commonly injury to the lower portion of the ureter during incision of a parametric abscess per vaginam, during the operation of removal of the uterus either for fibromyomata or malignant disease, usually the latter, and after removal of a urinary calculus impacted in the lower portion of the ureter through a vaginal incision. The operation is most frequently necessary in women on account of the conditions just mentioned.

(*b*) Injury to the pelvic portion of the ureter either during the performance of pelvic operations, or by stabs or gunshot wounds, when it is not feasible locally to repair the defect with a reasonable chance of success. These conditions are met with in both the male and female sex.

(*c*) After some operations upon the bladder for malignant growths, when it is necessary to remove that portion of the bladder wall into which the ureter opens.

Many operations have been practised, but in my opinion the soundest and best is a trans-peritoneal operation carried out through an incision in the lower part of the linea semilunaris of the affected side, or through a median incision.

Special instruments.—Deep moderately wide retractors, retractor speculum, urethral sounds, ureteral catheter, long urethral forceps, and fine fully curved needles and long needle-holder.

Position.—The patient is placed in the dorsal posture with the pelvis raised; the operator stands on the affected side of the patient, and his assistant opposite to him.

Operation.—(*a*) *Parietal incision, opening of peritoneal cavity, division of peritoneum along brim of pelvis and of broad ligament in female, dissection inwards of peritoneum, and exposure of ureter.*—An incision 3 to 4 inches long is made either in the lower portion of the linea semilunaris of the affected side or in the middle line below the umbilicus, preferably the former, since this, in my opinion, gives the better view, the strata of the abdominal wall are cut through and the peritoneal cavity opened. Next, the great omentum, coils of small intestine, cæcum, or pelvic colon are pushed upwards towards the diaphragm and packed away by the insertion of two or more large flat abdominal pads. This procedure will expose the floor and lateral walls of the pelvis together with the bladder and in the female the uterus and broad ligament on the affected side. When a woman is the subject of operation, the uterus should be packed over towards the sound side. The parietal peritoneum just below the pelvic brim is now divided for a distance of about 3 inches and also the infundibulo-pelvic ligament in the female, and the peritoneum dissected inwards as a flap. This separation is continued downwards and inwards until the ureter is exposed as it runs across the floor of the pelvis to join the postero-inferior aspect of the bladder. The ureter can be recognised by its cord-like appearance and feel. It will be found lying in the extra-peritoneal tissue and immediately underneath the peritoneum. When recognised, a silk ligature should be passed underneath it, which may be useful as a tractor at a later stage of the operation. During this dissection especial care must be taken not to injure any of the pelvic veins in the neighbourhood, since these are numerous and, if damaged, much troublesome hæmorrhage may be caused.

(*b*) *Determination of site of injury to ureter or of fistulous communication, ligature and division of ureter immediately above this, incision of bladder wall at site of anastomosis, and fixation of proximal end of divided ureter into this opening.*— The course of the ureter is traced downwards from the pelvic brim until the site of the fistulous opening is reached. This can generally be determined by feeling a localised induration, or, if any doubt exists, an assistant can be directed to pass a probe through the opening from below. When this has been decided, the ureter immediately proximal to the fistula is surrounded by a ligature of chromicised catgut and divided on the kidney side. The mucous lining of the centre of the stump formed by the distal end of the ureter is now cauterised with liquefied carbolic acid or an actual cautery and then protected with a small gauze pad. The proximal end of the ureter is lifted up and split vertically for a quarter of an inch with sharp scissors. This splitting is intended to avoid, if possible, a stricture at the spot where it is joined to the bladder. A fine suture of chromicised catgut is passed through each side of the split ureter in a U-shaped fashion, the convexity of the U being on the outer side of the tube, and the two free ends projecting through the mucous membrane towards the lumen. The proximal end of the ureter with the U sutures inserted is laid aside and protected with a piece of gauze. An assistant is next directed to cause the bladder wall to project at the site where it has been decided to make the anastomosis. This is done by passing a metallic sound into the bladder along the urethra and exerting pressure from within by means of this. In the female, a pair of long straight urethral forceps will be found to be more useful than the sound. The bladder wall having been made to project in this manner, the operator cuts through the projection with the scalpel for about ⅓ or ½ an inch. The two ends of each U-shaped suture are passed through the bladder wall from the cavity on each side, and then tied. The effect of this is to evert the two small flaps of the split end of the ureter and to fix them in close apposition to each margin of the opening which has been made in the bladder. Two or three other sutures of fine catgut are next introduced to strengthen this approximation around the other parts of the opening. This having been completed, closer fixation is brought about by the introduction of a second tier of sutures of fine silk, each suture passing through the fibrous and muscular coats of the ureter and bladder. The appearance of these sutures when tied, and the manner of fixation, is shown in Fig. 203, which represents a section of the bladder and ureter at the site of anastomosis. When the operation is being performed on a woman, much help may be afforded the operator by the assistant exerting traction on the implanted end of the ureter by the forceps which have been passed into the bladder through the urethra.

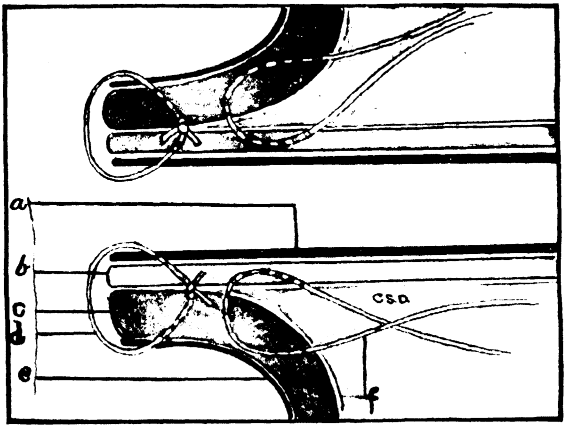

FIG. 203.—Suture uniting musculo-fibrous coats of ureter and bladder.

a. Mucous membrane of ureter.
b. Musculo-fibrous coat of ureter.
c. Musculo-fibrous coat of bladder.
d. U suture tied.
e. Mucous membrane of bladder.
f. Suture of second tier.

(*c*) *Closure of incision in peritoneum at brim of pelvis, repair of infundibulo-pelvic ligament in female, replacement of displaced viscera, closure of parietal wound and establishment of drainage if necessary.* The entire field of operation is sponged clean and dry after irrigation with saline solution, and the incision in the parietal peritoneum along the brim of the pelvis closed by the insertion of a continuous suture of chromicised catgut. The suture is commenced behind and terminated in front, and in the female the divided infundibulo-pelvic ligament is also sutured. Usually a small portion of this opening in the peritoneum should be left unsutured so as to permit of the introduction of a rubber drainage tube. This precaution is not necessary if there is no cystitis or other inflammatory condition in the neighbourhood. All protecting pads are now removed, the great omentum and intestines placed in their normal positions, and the external wound closed by the insertion of three tiers of sutures, a small portion being left unsutured when it is desired to put in a drainage tube. The incision in the corresponding linea semilunaris will be found more satisfactory for the establishment of drainage than the median incision.

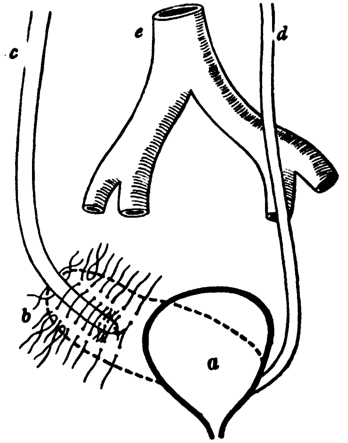

FIG. 204.—Uretero-vesical anastomosis (Witzel's operation).

a. Urinary bladder in normal position.
b. Urinary bladder pulled over to right after sutures have been inserted.
c. Right ureter.
d. Left ureter.
e. Aorta and common iliac arteries.

(*d*) *After-treatment.* — A self-retaining catheter should be kept in the bladder for a week or ten days, in order to give the sutured parts as much rest as possible, and urinary antiseptics such as helmitol or hexamine administered.

The results which have followed this operation have been very satisfactory, and in my opinion it ought to replace many of the uretero-ureteral operations upon the pelvic portions of the ureters.

Other methods of joining together the open end of the ureter and the bladder wall are depicted in Figs. 204 and 205.

In Witzel's operation (Fig. 204), which is performed extraperitoneally, the bladder is first of all pulled upwards into the iliac fossa of the affected side, and sutured in that position. The obliquely cut end of the ureter is then implanted, by means of a few interrupted catgut sutures, into an opening made into the bladder, and about 1½ to 2 inches of the ureter buried in the bladder wall by a series of Lembert sutures, introduced as shown in Fig. 204.

In Boldt's method (Fig. 205), ureteral implantation is simplified by the passage of a ureteral catheter.

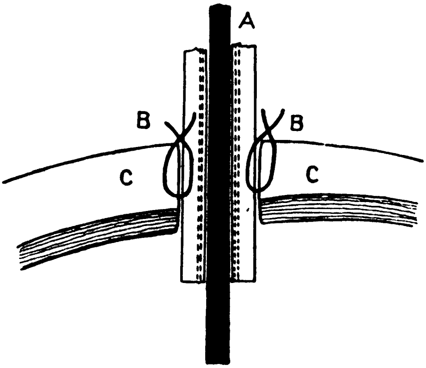

FIG. 205.—Uretero-vesical anastomosis (Boldt's method). Diagrammatic section showing position of sutures.

A. Catheter in ureter. B. Sutures. C. Bladder wall.

OPERATIONS UPON THE URINARY BLADDER

Puncture of the bladder.—*Indications.*—Puncture of the bladder is indicated in cases of acute distension, which cannot be relieved by the passage of a catheter; it may be adopted either as a temporary or a permanent measure. As a temporary measure it may be necessary, in cases of stricture, to tide over matters until such time as a filiform catheter or bougie can be passed into the bladder, or some more radical procedure, such as Wheelhouse's operation, can be carried out. Some cases of acute retention due to prostatic disease in which a catheter cannot be passed may also render its performance requisite, since it is dangerous at once to proceed to prostatectomy under these circumstances, even if the absence of severe vesical sepsis and kidney disease would otherwise seem to render this possible.

As a permanent measure it is indicated in those cases of enlargement of the prostate in which catheterisation is impossible, and either the nature of the growth or the condition of the renal functions forbids prostatectomy, or in which the patient will not entertain the idea of the more radical procedure being carried out.

(*a*) *Suprapubic puncture with the needle of an aspirator.*—The bladder is steadied by an assistant placing one hand on each side of the hypogastric region of the abdomen and applying pressure in an inward direction. A point is then selected immediately above the pubes, and the needle of the aspirator forced inwards, until the point has entered the cavity of the bladder. The urine is allowed to flow out, the flow being aided by gentle, continuous pressure from above.

Care should be taken that the point of the needle passes well into the interior of the bladder; otherwise, as the bladder contracts and its superior wall descends, the needle may slip out before all the contained urine has been drawn off.

This proceeding may be repeated at intervals, but it is not advisable to trust to this method of evacuation for any considerable length of time. When the wall of the bladder has once been punctured in this way, the urine should not be allowed to collect so as to distend the organ considerably, otherwise the point of puncture may leak, and urine pass into the adjacent tissues.

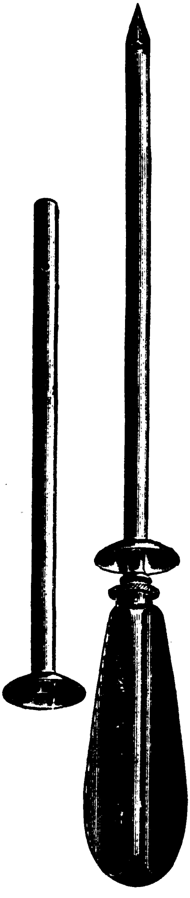

FIG. 206.—Trocar and cannula for suprapubic puncture of the bladder.

(*b*) *Suprapubic puncture with a trocar.*—A point is selected in the hypogastric region immediately above the pubes, and then a straight trocar and cannula (Fig. 206) pushed into the bladder through the abdominal wall. The trocar is withdrawn, leaving the cannula in position, and through the lumen of this a soft rubber catheter is passed into the bladder. The cannula may be fixed in position for a few hours and then removed, the catheter being left.

The suprapubic method of puncture of the bladder is the one now almost universally practised, although formerly it was not uncommon to perform this operation through the rectum or perineum. The numerous disadvantages of the latter methods, however, render their adoption quite unjustifiable.

Litholapaxy.—The term litholapaxy implies the removal of a stone from the urinary bladder at one sitting, by crushing it with an instrument called a "lithotrite" (Fig. 207) (which is introduced into the cavity of the bladder along the urethra), and immediately evacuating the fragments. The name "lithotrity" is often given to the operation, but this term ought to be limited to that form of operation in which the calculus is crushed at several sittings, and the fragments are allowed to be evacuated along with the stream of urine.

Removal of urinary calculi by crushing has replaced to a considerable extent the operation of lithotomy.

Indications.—Litholapaxy is indicated in all cases of calculus in the urinary bladder in which the stone can be safely grasped with the blades of the lithotrite, and is of a consistency which will allow of crushing without danger of breaking the instrument. In some cases of oxalate of lime or pure uric acid calculi, the stone is so hard that it cannot safely be crushed. Again, when very large stones (above 1½ oz.) are present, it is only possible to remove them by lithotomy; but it may be said that, in the majority of cases in which the calculus can be grasped between the blades of the lithotrite, it will be possible to remove it by crushing, unless it is very hard and dense, or very soft. Some surgeons have said that the operation ought not to be performed on young boys, but this statement appears to have been made without sufficient data, since it has been clearly shown that calculi can be easily and safely removed from the interior of the bladder of young male children by crushing.

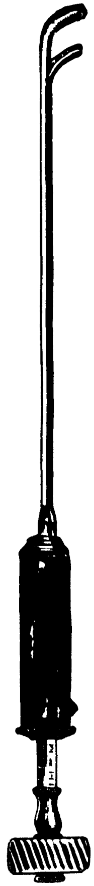

FIG. 207.—Litholapaxy. Lithotrite.

Preparatory treatment.—The patient should be kept at rest for a few days previous to the operation, and fed on light, nonirritating food. If a stricture of the urethra is present it should be gradually dilated until a full-sized catheter (No. 14 E.) can be easily introduced. The patient should be directed to retain his urine for an hour or more before the time of operation.

Special instruments.—Scalpel (to enlarge meatus if necessary), lithotrites of different sizes, evacuator and evacuating catheters, Porge coudée catheter (No. 20 F.), and injection syringe cystoscope.

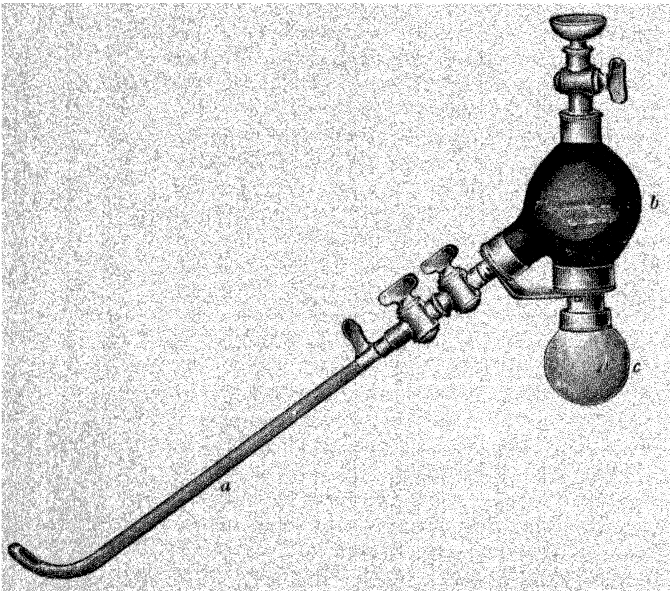

FIG. 208.—Bigelow's evacuator, for use in litholapaxy.

a. Evacuation cannula. *b.* Rubber compression bulb.
c. Receptacle into which fragments of calculus fall.

Position.—The patient is placed in the dorsal position, near the right side of the operating table, with the buttocks slightly raised, and the legs extended and slightly separated ; the surgeon stands on the right side, and the chief assistant opposite to him.

Operation.—The actual operation of litholapaxy can be divided into two stages, namely—(*a*) The introduction of the lithotrite, and crushing of the stone into small fragments ; and (*b*) removal of the fragments from the interior of the bladder with the evacuator.

(*a*) *Introduction of lithotrite and crushing of stone.*—The natural urine, if uninfected, contained in the bladder may be utilised as the medium in which to crush, or if it is preferred, this may be withdrawn and from 4 to 6 oz. of warm boracic solution introduced, and then the patient is ready for the introduction of the lithotrite. The instrument is warmed and oiled, and then carefully passed along the urethra, care being taken not to allow the tip to catch against the anterior layer of the triangular ligament. This accident is avoided by allowing the instrument to pass along the urethral canal chiefly by its own weight, and not depressing the handle until the prostate has been reached. When the lithotrite has entered the bladder it is allowed to pass lightly over the trigone, so as to detect the locality of the stone. If the calculus can be felt on one side, the blades of the instrument are turned to the other, the male blade is carefully separated from the female one, and then they are turned towards the stone and gradually closed so as to fix it between the blades. If the stone is not felt at first the blades of the lithotrite should be separated, the handle slightly raised so as to depress the blades, and then often the stone will fall in between them, in which case they are closed. If these manœuvres fail, the blades are opened and carefully turned from side to side, so as to explore the area of the trigone and the adjacent portions of the bladder; and if these measures are not successful, the handle should be depressed so as to raise the point of the instrument into the middle of the cavity of the bladder, and then turned round, and the floor examined with the blades in the reversed position. When these directions are systematically carried out it will rarely happen that the surgeon fails to grasp the stone with the blades of the lithotrite. The calculus having been fixed by the lithotrite, it is lifted towards the centre of the cavity of the bladder, and then the blades are screwed home and the calculus broken into fragments. These usually fall into the position in which the calculus was first found, and hence it is an easy matter to repeat the procedure of seizing a portion of the calculus, lifting it to the centre of the cavity of the bladder, and then crushing it. This is repeated until the entire caculus has been reduced to small fragments, and then the blades are closed and the instrument withdrawn.

(*b*) *Removal of the fragments.*—An evacuating tube is next introduced, and the evacuator filled with a dilute solution of warm boracic acid, and connected with the tube. Pressure is now carefully applied to the bag of the evacuator and 2 or 3 oz. of fluid are forced into the bladder.

Pressure is then relaxed, and the fluid is drawn back into the bag of the evacuator, carrying with it a number of the fragments. This procedure is repeated until all the fragments of the calculus have been removed. After each relaxation of pressure on the bag of the evacuator, a short time should be allowed to elapse before the fluid is again forced into the bladder, so as to permit any fragments which have passed into the interior of the tube to pass out if possible. If any of the pieces of the stone are too large to pass through the evacuating tube, either a larger one must be introduced or the lithotrite must be again used, so as to reduce them to fragments of smaller size. When there is difficulty in washing out the last few fragments, it will often be found to be advantageous to detach the evacuator and allow as much fluid as possible to pass out from the bladder, aiding the flow by suprapubic pressure, and then again to attach the evacuator and wash out as before. Finally, the bladder must be examined through the cystoscope, to make certain that all fragments of stone have been removed.

After-treatment.—The patient is kept at rest for a few days after the operation, and a catheter is passed to empty the bladder if necessary. As a final procedure it is wise to pass a cystoscope to make certain that no small fragments have been overlooked, as in prostatic cases they are very likely to form the nucleus of a fresh stone. The occurrence of rigors and urethral fever is said to be more common after the operation of litholapaxy than after lithotomy, and by some surgeons a recurrence of the stone is thought to be more frequent.

Suprapubic cystotomy.—The operation of suprapubic cystotomy consists in making an aperture into the bladder through the hypogastric region of the abdomen.

Indications.—This operation is indicated in the following conditions :—

(*a*) The presence of calculi within the bladder which are too large or too hard to be easily crushed by the lithotrite, or in cases of stone complicated by the presence of marked prostatic enlargement, or when the general condition of the patient is not favourable for the performance of a prolonged operation.

(*b*) The presence of an encysted calculus of the bladder.

(*c*) The removal of certain forms of intravesical tumour.

(*d*) The removal from the interior of the bladder of foreign bodies which cannot readily and with safety be extracted through the urethra.

(*e*) In some cases of solitary tuberculous ulcer of the bladder, or as a means of drainage in the later stages of the disease.

(*f*) In cases of encapsuled adenomatous tumours of the prostate.

Special instruments. — Catheter and injection syringe or irrigation apparatus. When the operation is performed for stone, or the removal of a foreign body, lithotomy forceps and scoops will also be required; and when a tumour is being removed, special long slender clamp forceps, curved at the tip, and a fully curved needle on a handle.

Position.—The patient is placed either in the dorsal or in the raised pelvic (" Trendelenburg ") position, the surgeon stands on the left side of the patient, and the chief assistant opposite to him.

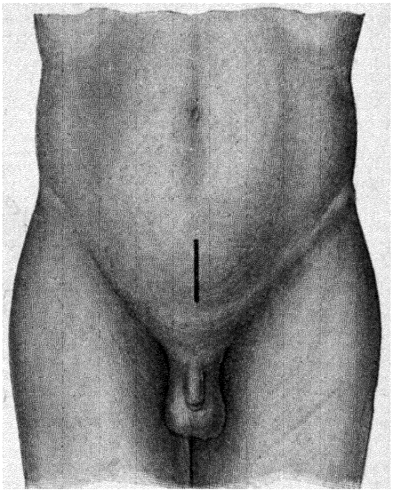

FIG. 209.—Suprapubic cystotomy. Position of abdominal incision.

Operation.—The operation may be divided into the following stages, namely :—

(*a*) *Evacuation of the bladder and distension with fluid.* — When the patient has been anæsthetised a catheter is introduced into the bladder, and all the fluid contents drawn off. An injection syringe or irrigation apparatus is filled with warm boracic acid solution, and usually about 8 to 10 oz. are injected, but this amount varies according to the irritability of the bladder walls; in many cases of cystitis not more than 3 to 4 oz. can be introduced. Enough fluid should be injected into the bladder (if the condition of its wall will allow) to enable the surgeon to feel the fundus half-way between the pubes and the umbilicus. The catheter is removed, and a bandage or piece of rubber tubing tied round the penis, if necessary, to prevent the escape of the fluid.

(*b*) *Parietal incision.*—A vertical incision from 2 to 3 inches in length is made, which commences about ½ inch below the upper border of the pubic symphysis, and extends upwards towards the umbilicus. The abdominal wall is divided, if possible, through the interval between the two recti muscles; and in order to make this distinct, when the deep fascia has been cut through, an incision may be made transversely in the line of the pubic crests. The interval between the muscles is incised, and the margins of the wound held apart with retractors. The fascia transversalis is then divided, care being taken not to notch the peritoneum in the upper part of the incision. The loose connective tissue which fills the prevesical space is now exposed, and often has a yellow appearance, owing to the presence of fat in its meshes. This tissue is carefully broken down either with the fingers or with dissecting forceps, and then the wall of the bladder becomes visible. This can be recognised by its brownish-red colour, by its tenseness, and by its muscular

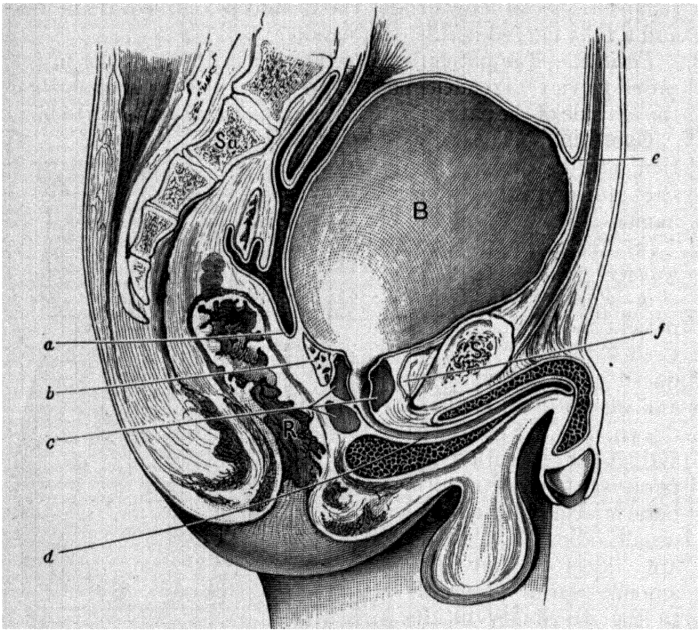

FIG. 210.—Mesial section through a male pelvis, in which the bladder is greatly distended.—CUNNINGHAM.

a. Reflection of peritoneum, from bladder to rectum.
b. Ductus (vas) deferens.
c. Prostate.
d. Urethra.
e. Peritoneal reflection, from fundus of bladder to anterior abdominal wall.
f. Retro-pubic or ante-vesical pad of connective tissue and fat.
B. Urinary bladder.
R. Rectum.
S. Symphysis pubis.
Sa. Sacrum.

fibres. In this part of the operation a well-marked venous plexus is not infrequently met with. It is essential to clamp these vessels before division, otherwise troublesome hæmorrhage

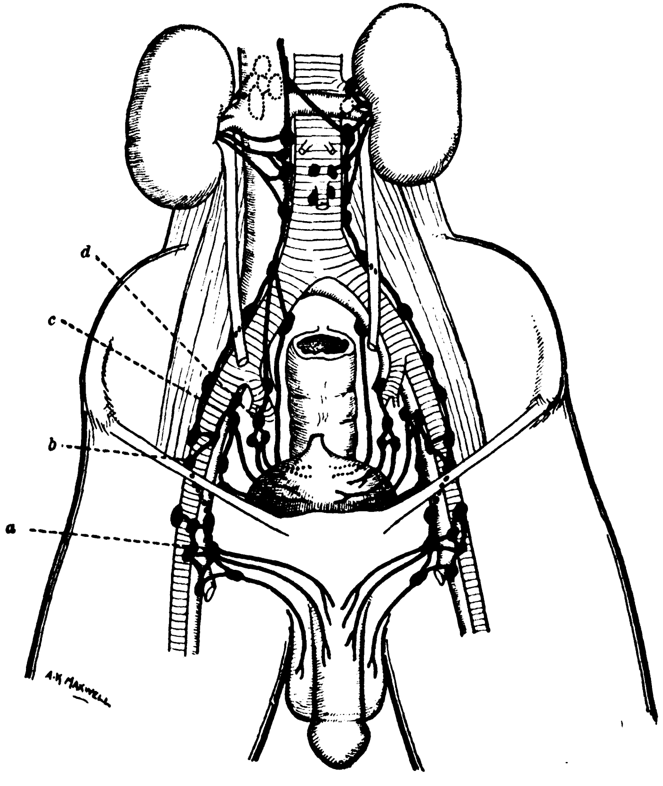

FIG. 211.—Arrangement of lymph glands and lymph vessels from urinary bladder and skin of penis—semi-diagrammatic.

a. Superficial lymph glands in femoral region.
b. Lymph glands along external iliac vessels.
c. Lateral pelvic lymph glands.
d. Lymph glands along hypogastric (internal iliac) vessels.

will be encountered. The prevesical space ***must not be opened up too extensively,*** only such an area of the bladder being exposed as is sufficient to allow of the further procedures being carried out.

(*c*) *Opening of the bladder.*—Two sutures of No. 4 silk in curved needles are passed through the wall of the bladder ½ inch apart, and situated one on either side of the middle line below the attachment of the urachus. These are used as retractors, one held by the surgeon and one by an assistant. A scalpel is forced through the wall of the bladder between the silk retractors, and an incision made downwards and towards the pubes, at first not more than 1 inch in length. If the retractors are held well up, little of the contents of the bladder will escape, and the bulk may be syphoned out into a bowl. The finger is next passed into the interior of the bladder, and the presence and locality of a foreign body, calculus, or new growth determined. This investigation may be facilitated by the use of an electric head-lamp and small caisson, or retractor speculum, by which the interior of the bladder can be illuminated, and a very good view of the mucosa obtained. A bent sound is also very useful in locating calculi or foreign bodies.

(*d*) *Performance of intravesical manipulations.*—The procedure during this stage of the operation depends upon the nature of the affection from which the patient is suffering. When a calculus is present it is removed with a lithotomy scoop or forceps, preferably with the latter, since less injury to the adjacent tissues is likely to follow the use of forceps than when either a scoop or the fingers of the surgeon are used. Usually little difficulty will be experienced in removing calculi from the bladder after the cavity of the viscus has been opened. In old people, however, in whom the calculus is very large, and the walls of the bladder have undergone considerable thickening, difficulty may be met with in extracting the stone. Much help is often afforded by an assistant passing his fingers into the rectum and manipulating the stone from below. In all cases great care must be taken not to make a larger incision in the bladder wall than is necessary, or to cause any bruising or laceration of the margins of the incision, or the parts of the wall of the bladder which lie in contact with the stone. During the removal of a foreign body, the exact form and size should be ascertained before attempting its extraction, so as to avoid further damage if the body happens to be a sharp one. Usually a foreign body can be readily extracted with the fingers or a fine pair of long-bladed forceps. When a pedunculated papilloma or villous tumour is present, the pedicle is seized with a long slender clamp curved at the tip, and the exuberant portion of the growth removed ; this enables a much better view of the site of attachment to be obtained. Traction is now made upon the stalk of the tumour, so as to pull upwards a conical-shaped piece of mucous membrane, and through the base of this a continuous mattress suture of catgut is passed and tied. With a pair of curved scissors the base of the cone is divided between the suture and the clamp, and the remainder of the growth with an attached piece of mucous membrane removed. Dealt with in this way, bleeding of any consequence is rarely met with, and by taking away the tissues from which the tumour is growing the liability to rapid recurrence is diminished. Sessile papillomatous masses and malignant disease, if of limited extent and situated upon an accessible part of the bladder, must be treated by partial resection of that viscus, a uretero-vesical anastomosis being performed if the region of either ureter is involved. After removal of a papilloma the bare area of the bladder may be treated with the actual cautery.

(*e*) *Closure of wound in bladder and parietes.*—The question as to whether the *vesical* wound ought to be sutured or not depends upon the condition of the bladder walls at the time of the operation. If severe cystitis is present it is not desirable that this should be done, as in a suprapubic wound we have at our disposal by far the best means of drainage that can be adopted in these cases. The bladder can be irrigated through the opening with some mild antiseptic lotion twice or more daily, and all risk of strain upon the perhaps already seriously damaged kidneys avoided. Again, where a certain amount of oozing is expected, as in prostatectomy cases, a large drainage tube enables the clots of blood to be washed out, and the serious danger of a bladder filled with decomposing clot is thus averted.

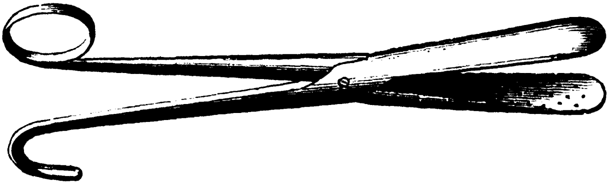

FIG. 212.—Suprapubic cystotomy. Lithotomy forceps.

When the vesical wound is to be closed, and this should be done whenever it is possible, it is carried out in the following manner: A couple of catgut sutures are first passed through the angles of the bladder incision and given to an assistant to hold, and then the remainder of the opening in the bladder is closed by a continuous suture of fine catgut taking up all the coats of that viscus. If necessary, a second tier of interrupted Lembert sutures of catgut are inserted to strengthen the wound. The parietal incision is now approximated in the usual manner, with the exception that about ½ inch at the lower angle is left open and a fine drainage tube passed down to the region of the wound in the bladder, so as to allow the escape of urine and any exudation which may occur if the suturing has not been perfect, or the wound does not heal by primary union. In cases in which it has been decided to employ suprapubic drainage for a time, it will occasionally be found advisable to fix the margins of the incision in the bladder to those of the rectus muscle by the insertion of a few points of suture, and if the external wound is large the upper part may be closed.

After-treatment.—When the wound has been closed a soft rubber catheter should be passed into the bladder through the urethra and kept there for a few days, so as to allow the escape of urine as it is secreted, and prevent distension of the viscus, which might separate the margins of the wound and allow the urine to escape, and so delay healing. When the wound is left open, the best method of after-treatment is that indicated in the section dealing with prostatectomy by the suprapubic route (see p. 305).

Lateral lithotomy or cystotomy.—In the operation of lateral lithotomy an oblique incision is made in the perineum, and deepened until the interior of the bladder is reached. It is performed for the extraction of vesical calculi and the removal of foreign bodies from the interior of the male bladder, and appears to be specially suitable for children, but it is doubtful whether it possesses any material advantages even in them over the suprapubic route. This operation has been almost entirely superseded by the suprapubic variety, and the increasing practice of litholapaxy.

Special instruments.—Sound, lithotomy knife, curved lithotomy staff with a left lateral groove, lithotomy forceps and scoop, and perineal drainage tube.

Position.—The patient is at first placed in the dorsal position while the staff is being passed and the presence of stone confirmed, and then he is put in the lithotomy position for the remainder of the operation. The surgeon sits opposite the perineum, and an assistant stands on each side.

Operation.—The operation may be subdivided into three stages, namely :—

(*a*) *Passage of staff.*—While the patient lies in the dorsal position, the surgeon passes the grooved staff, which should also be made to strike the stone into the bladder. The patient is next placed in the perineal position, the buttocks projecting slightly over the end of the table, whilst the surgeon seats himself directly opposite the perineum. The scrotum is drawn upwards, and the assistant directed to depress the handle of the staff towards the front of the abdomen, where it may be steadied against the front aspect of the body of the pubes. This

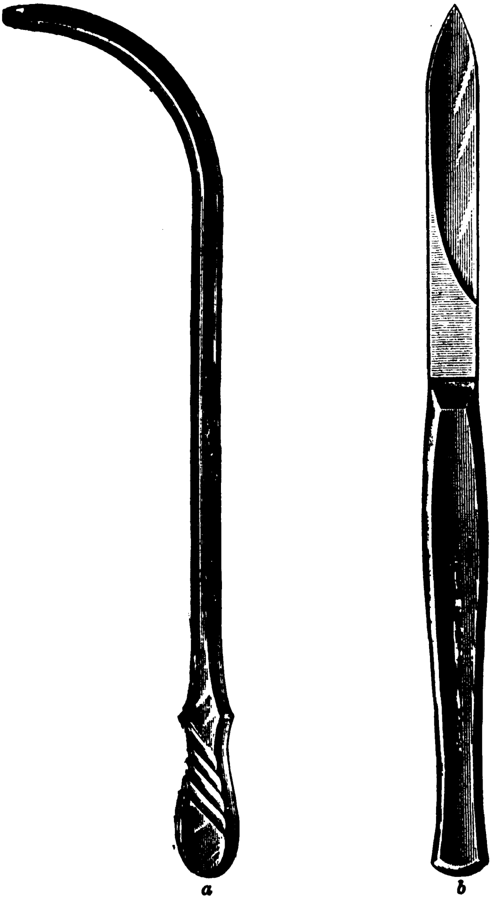

FIG. 213.—Lateral lithotomy.

a. Staff with left lateral groove. *b*. Special form of knife for use in lateral lithotomy.

manœuvre lifts the membranous portion of the urethra towards the perineum, and renders the long axis of the canal almost parallel with the surface of this region.

(*b*) *Perineal incision.*—One point is selected 1¼ inch in front of the anterior margin of the anus, and immediately to the left of the medium raphé, and another one-third of the distance from the left ischial tuberosity to the lateral margin of the anus ; the lithotomy knife is taken, and the blade being held parallel with the line of the proposed incision, is pushed inwards at the first point until the staff is reached ; it is then made to cut outwards to the second point in the ischio-rectal fossa. The tissues are divided by a kind of sawing movement, and the incision made in this manner measures from 2 to 3 inches in length. The surgeon again introduces the knife, the point being placed in the groove of the staff and the cutting edge of the blade directed rather more towards the left, and then pushes it forwards into the interior of the bladder. The point of the knife must not be allowed to leave the groove in the staff as it is pushed into the bladder, otherwise difficulties may be met with. The knife having been withdrawn, the forefinger of the left hand is placed in the concavity of the staff, and follows it into the interior of the

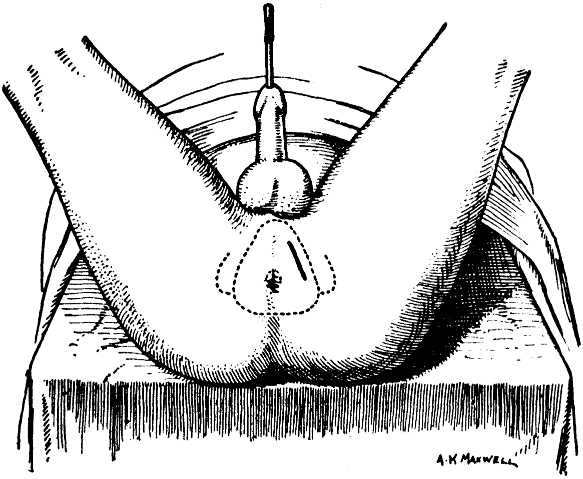

FIG. 214.—Lateral lithotomy. Position of patient and line of perineal incision.

bladder, the incision in the neck of the bladder and prostate being made large enough for the finger to pass in easily. The moment when the knife has entered the bladder is recognised by a diminution of the resistance to the cutting edge, and also by a gush of fluid from the interior of the bladder. When the finger is within the bladder, the staff is withdrawn and the calculus felt for.

(*c*) *Finding and extraction of stone or foreign body.*—When its position has been made out, the lithotomy forceps are passed into the interior of the bladder along the palmar surface of the finger, and the stone seized with the blades and extracted. If possible, the long axis of the stone should be grasped with the forceps, so as to avoid unnecessary laceration of the tissues of the perineum during its extraction. In some cases a scoop will be found more useful than forceps, but usually the calculus can be extracted better and more easily with the latter. The forefinger can often manipulate the stone between the blades of the forceps, and make the long diameter of the calculus correspond with that of the instrument. Before concluding the operation, the interior of the bladder should be examined for other calculi.

When all calculi have been removed, the interior of the bladder is irrigated with an antiseptic solution, a perineal drainage tube placed in the bladder, and the wound packed with tampons of gauze around the tube.

The chief difficulties which may be met with during the performance of the operation of lateral lithotomy are inability to find the bladder, injury to the artery of the bulb, or to the internal pudendal artery, or injury to the rectum. The inability to find the cavity of the bladder is generally due to the surgeon allowing the point of the knife to leave the groove in the staff before the bladder has been reached ; and in children, owing to the elasticity of the tissues, the prostate and neck of the bladder may recede before the tip of the exploring finger ; injury to the artery to the bulb is caused by making the incision too far forwards ; and injury to the pudendal (internal pudic) artery by cutting too far outwards towards the ischial tuberosity ; whilst damage to the rectum is caused either by cutting too far backwards, or by not lateralising the knife sufficiently during the second stage of the operation.

Median lithotomy or cystotomy.—This is an operation which is very rarely performed. An incision is made in the middle line of the perineum a short distance in front of the anus, and deepened until the membranous portion of the urethra and the interior of the bladder has been reached.

Treatment of rupture of the urinary bladder.—Ruptures of the bladder are of two kinds—intra-peritoneal, when the rent causes the establishment of a communication between the cavity of the bladder and that of the peritoneum ; and extra-peritoneal, when the solution of continuity in the bladder wall involves that portion which is not covered by peritoneum. An intra-peritoneal rupture of the bladder is situated on the superior surface or upper portion of the base of the viscus. An extra-peritoneal rupture of the bladder is usually situated on one of the infero-lateral areas, or in the region of the neck, but it may involve any part of the organ which is not covered by peritoneum.

Indications.—All cases of rupture of the bladder in which the diagnosis has been established, and in which the condition of the patient will allow an operation to be performed.

It is important that an operation should be at once undertaken when the existence of a rupture has been diagnosed. This is especially the case in intra-peritoneal rupture.

Special instruments.—Blunt hook, sponge-holders, catheter, needles (fine curved), needle-holder, and retractor speculum.

Position.—The patient is first placed in the dorsal posture, and subsequently raised into the Trendelenburg position if the tear is situated deeply in the pelvis; the surgeon stands on the left side of the patient, and the assistant opposite to him.

Operation (*for intra-peritoneal rupture*).—The operation may be conveniently divided into three stages—(*a*) Abdominal incision, opening of the peritoneum, and finding the rupture ; (*b*) closure of the rupture ; and (*c*) closure of the external wound.

(*a*) *Abdominal incision, opening peritoneum, and location of rupture.*—A median incision is made, commencing immediately above the pubic eminence, and extending upwards for 4 in. or more towards the umbilicus.

The various strata of the abdominal wall are divided until the parietal peritoneum and the summit of the bladder are exposed. At this stage it occasionally happens that laceration and ecchymosis of the apex or inferior surface of the bladder become visible ; if this is so, the extent of the injury should be made out.

The peritoneum is now incised, and usually much fluid, chiefly blood-stained urine, will escape. With sponges, all urine and other fluid is removed from the peritoneal cavity ; and then the visible coils of intestine are pushed upwards and held out of the way by the insertion of one or two large abdominal pads.

The bladder is now carefully examined, in order to find the situation of the rent. When this has been found, its size and extent are ascertained. The interior of the bladder should also be examined by passing the finger through the rupture, and should be sponged dry so as to remove all blood-clots which may be present. A blunt hook is now placed in the upper angle of the rupture and given to an assistant to hold, to facilitate the introduction of the sutures.

(*b*) *Closure of rupture.*—Two tiers of sutures should be inserted for the closure of the rupture, the first consisting of a continuous suture of chromicised catgut, which takes up all the coats of the bladder. If silk be used for the mucous membrane, there is a possibility that at a later period salts from the urine may be deposited upon it. If interrupted sutures are used, all should be inserted before any are tied, and they should be placed one-sixth of an inch apart. When they have been introduced they are tied, the lowermost ones first, and their ends cut short.

The sutures of the second tier are of fine silk. Each suture is introduced after Lembert's method, and transfixes the serous and muscular coats of the bladder wall on each border of the rent. The insertion of these sutures is commenced at the lower angle of the rupture ; they are placed at intervals of one-fourth of an inch, or even less if necessary, until the entire aperture has been closed. The sutures should extend a short distance above and below the limits of the rupture. All are inserted, then they are tied and their ends cut short. In cases where the rupture extends into the base of the bladder, it will be found convenient to introduce the first suture a short distance above the lower angle, and then to use this one to lift up the lower part and facilitate the introduction of the lowest sutures.

(*c*) *Closure of the external wound.*—The region of the rupture is sponged dry, the pads which have been used to keep back the intestines are removed and the entire exposed part of the peritoneal cavity freed from blood or blood-stained urine, and the displaced viscera replaced in their usual position. Care must be taken not to leave behind a collection of fluid at the bottom of the pelvis.

The parietal wound is then closed in the usual manner by the insertion of two or three tiers of sutures.

If there is commencing peritonitis, or there has been much escape of urine into the peritoneal cavity, it is advisable to irrigate the entire peritoneal cavity with warm saline solution, and to leave open the lower angle of the wound and to pass a rubber draining tube into the bottom of the pelvis. This can be removed in most cases on the following day. It will allow any urine or fluid which has been left behind, or which may be subsequently secreted by the peritoneum, to escape.

A soft rubber catheter is passed into the bladder along the urethra and tied in position, and provision is made for the collection of the urine as it trickles away. This precaution avoids distension of the bladder, and hence promotes quick union of the sutured margins of the rupture. The catheter should be changed daily, and can be permanently removed at the end of a week or ten days. The strictest aseptic precautions must be observed in connection with the passage of the catheter, in order to avoid the occurrence of cystitis.

Operation (*for extra-peritoneal rupture*).—When the inferior aspect of the bladder has been exposed, through an incision similar to the above, the regions of the neck and infero-lateral areas are carefully examined in order to locate the rupture. If this is situated in the exposed area, the interior of the viscus is sponged dry, and then the margins of the rupture are united in the manner described above. When no trace of a tear can be discovered on this aspect, the peritoneum may be incised for a short distance, and the peritoneal aspect of the organ exposed. If no sign of rupture becomes visible, the opening in the peritoneum is closed.

When the symptoms point to unmistakable rupture, and the rent has not become visible by the previous procedures—a condition which very rarely occurs—an incision should be made in the inferior aspect of the bladder, as in the manner described in suprapubic cystotomy, and through this opening the base of the viscus and the region of the prostate can be examined. If a rupture is discovered, the margins are sponged dry and united by a series of catgut sutures, introduced from the interior of the bladder. In these cases it is usually advisable to provide for perineal drainage, and then the wound in the inferior aspect of the bladder is closed in the ordinary manner. The abdominal wound is only partially closed in cases of extra-peritoneal rupture, the lower part being left open, and through this a drainage tube is passed down towards the region of the rupture.

The further treatment of extra-peritoneal rupture is similar to that described in connection with the other form.

Operations upon the Prostate

Anatomical considerations.—The prostate is a somewhat conical-shaped gland which surrounds the prostatic urethra. At its base it is structurally continuous with the musculature of the bladder, the longitudinal fibres of which can be traced downwards into the prostatic substance, where they spread out and are gradually lost. The prostate is in relation above with the anterior half of the trigone and a small portion of the inferior surface immediately in front of the neck of the bladder, but the base of the gland under normal circumstances is separated from the cavity of the bladder by the mucous membrane and muscle of the trigone, and in the region of the internal urinary meatus by the internal sphincter in addition. When the prostate, however, is the seat of an adenomatous growth, the latter pushes its way upwards into the interior of the bladder within the ring of the internal sphincter, so that under these circumstances a thinned-out layer of mucous membrane alone separates the intravesical projection from the examining finger passed into the bladder through a suprapubic opening. The apex of the gland rests upon the upper aspect of the deep layer of the progenital diaphragm (triangular ligament), and it is here that the urethra leaves it.

In front, it is separated from the pubic bone by the retropubic pad of fat; behind, a transverse membranous septum (the recto-vesical layer of pelvic fascia) intervenes between its posterior surface and the anterior rectal wall; whilst, laterally it is embraced by the anterior converging fibres of the levator ani. The prostate is enclosed in, and is firmly anchored in position by, the *prostatic sheath*, which is only deficient above where the base of the gland fuses with the bladder. Laterally and behind, this sheath is a strong membranous structure, and is formed by the recto-vesical layer of the visceral pelvic fascia, whilst in front, where it is continuous with the vesical layer, it is looser and more cribriform in its arrangement. Running upwards in this anterior portion is the prostatic plexus of veins, the main lateral vessels of which then turn backwards in the vesico-prostatic groove to empty into the inferior vesical plexus.

On section the prostate is seen to consist of two portions, a medullary and a cortical. The medulla is mainly composed of adenomatous tissue, which is placed as a crescentic-shaped mass behind and at the sides of the urethra; passing transversely across in front of the urethra, and connecting the horns of the crescent, is a band of unstriped muscle, the anterior commissure. The cortex of the gland is composed of fibrous and both striped and unstriped muscular tissue, but also contains a certain number of glandular elements.

In the more usual form of adenomatous enlargement, this cortical portion, together with the fibro-muscular stroma of the medulla, become converted into a laminated pathological capsule. The line of cleavage in suprapubic prostatectomy lies actually in this capsule, and the tumour removed consists of one or more grouped adenomata, containing the urethra and sometimes the common ejaculatory ducts, and showing on its surface a number of strands of tissue derived from the pathological capsule. The prostatic cavity, which results from this procedure, is bounded from within outwards by—(*a*) The pathological capsule ; (*b*) the veins of the prostatic plexus, actually embedded in or lying deep to the " prostatic sheath " ; and (*c*) the prostatic sheath of pelvic fascia.

Prostatectomy.—The removal of the prostate by a surgical operation is called prostatectomy, and may be accomplished either through a suprapubic opening in the bladder or by means of a perineal incision. In suprapubic prostatectomy an adenomatous mass containing the prostate urethra is enucleated from within its *pathological capsule* ; in this operation the common ejaculatory ducts, embedded in a mass of condensed prostatic tissue at the most dependent portion of the gland, may escape, but they are usually found buried in the growth. In perineal prostatectomy the greater part or whole of the prostate may be removed from within its sheath of pelvic fascia.

Indications—

(*a*) Innocent enlargement of the prostate in which one or more of the following conditions are present :—(i) Pain, hæmorrhage, or obstruction rendering regular catheterisation impossible ; (ii) repeated attacks of acute retention ; (iii) residual urine amounting to 4 oz. or more, when either catheterisation once daily fails to relieve the symptoms, or the patient cannot be trusted to carry out rigid asepsis ; (iv) cases suffering from cystitis, in which the kidneys have not been seriously involved by an ascending infection ; and (v) vesical stone.

(*b*) Malignant disease of the prostate, in which the prostatic sheath is not infiltrated, and the base of the bladder not extensively involved.

A careful preliminary examination of the urine should always be made, and no case subjected to operation in which there is reason to believe that the renal functions have been dangerously impaired by atrophy or sepsis.

Choice of operation.—Encapsuled tumours of the prostate should be treated by suprapubic enucleation, whilst the non-encapsulated variety is better dealt with by perineal excision. In the former variety of operation a much larger tumour can be delivered through the suprapubic opening than it is possible to remove by the perineal route, and the operation is more easily and rapidly performed, whilst it appears to give uniformly good results. Again, such distressing sequelæ as epididymitis and incontinence of urine are certainly not so common after the suprapubic operation.

Non-encapsulated adenomata (the so-called " fibrous " prostate), which have to be removed with scissors and often come away piecemeal, and early malignant disease, in which resection of part of the bladder may be necessary, are more easily and satisfactorily dealt with through a perineal incision. Recently perineal prostatotomy appears to have met with much success in the treatment of prostatic obstruction due to the small, hard, " fibrous " prostate.

The essential features in this operation are the exposure of the urethra at the apex of the prostate through a perineal wound, and section of the posterior portion of the gland. This is effected by opening the urethra, passing a blunt-pointed bistoury into the prostatic canal, and cutting directly backwards.

I. Suprapubic prostatectomy.—

Position.—The patient is usually placed in the dorsal position, but in the case of very large tumours their removal is undoubtedly facilitated by adopting the Trendelenburg posture. The surgeon stands upon the patient's left, with his assistant opposite him.

Operation.—The operation may be divided into the following stages, namely :—

(*a*) *Suprapubic cystotomy.*—This is done by the method described on page 289 *et seq.*, the bladder having been first washed out and then distended with 8 to 10 oz. of boracic lotion introduced through a " Coudée " catheter (Porge, No. 20 F.). The point of the instrument is withdrawn into the bulbous urethra, but it is not completely removed.

(*b*) *Enucleation of the prostate.*—The bladder having been opened, a careful preliminary survey of its interior is made first of all, any stone which may be present removed with lithotomy forceps, and the type of prostatic enlargement made out.

Enucleation of the gland may be commenced either at a point immediately behind the internal urinary meatus or, if preferred, over the most prominent part of the intra-vesical projection. From what has already been said it will be clear that the prostate is only separated from the bladder by a thinned-out layer of mucous membrane. Two fingers of the left hand of the surgeon, protected by a rubber glove, are now passed into the rectum, and by this means the prostate is pushed upwards and forwards, and at the same time steadied from below.

The mucous membrane over the tumour is incised with a scalpel or scissors, and then by a little judicious pressure the finger can be made mechanically to enter the line of cleavage, or, in other words, to pass onwards amongst the innermost layers of the pathological capsule. The prostate is now separated from its bed by working systematically round it, beginning on one lateral aspect and ending in front. The wound made by the finger is gradually deepened until the apex of the gland situated upon the superior layer of the urino-genital diaphragm (deep layer of triangular ligament) is reached. Here a little difficulty may be met with, as the urethra has to be broken through just where it leaves the prostate to pass into its membranous portion. This having been done, the tumour is free, can be brought up out of the prostatic cavity, and delivered through the suprapubic wound either with the fingers or forceps. Somewhat free bleeding occurs for the first minute or so, but this is rarely dangerously profuse, and it can be rapidly controlled by once more pushing onwards the catheter, and irrigating the bladder with hot lotion at a temperature of 110° to 115° F. This should not be con-

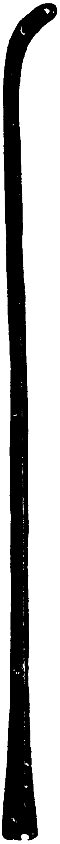

Fig. 215.—Porge "Coudée" catheter.

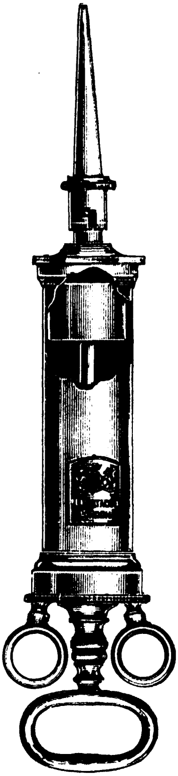

Fig. 216.—Metal syringe for filling bladder with fluid.

tinued for more than 2 to 3 minutes, and whilst it is being done the prostatic cavity may be squeezed from the rectum and helped to contract. The surgeon now withdraws the fingers of his left hand from the bowel, a nurse removes his glove, and he once more thoroughly sterilises his hands. A tag of urethral mucous membrane sometimes remains in situ in relation to the inner surface of the progenital diaphragm (triangular ligament). It should be removed with a pair of curved scissors, as it is liable to cause obstruction at the commencement of the membranous urethra.

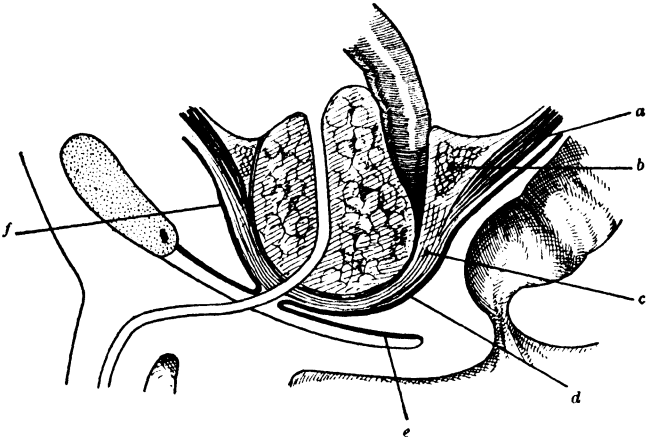

FIG. 217.—Diagrammatic representation of suprapubic enucleation of an adenomatous prostate. The dark line represents the line of cleavage.

a. Longitudinal muscular fibres of bladder.
b. Internal sphincter.
c. Pathological capsule of adenoma.
d. Recto-vesical layer of visceral pelvic fascia.
e. Superior layer of the urino-genita, diaphragm (parietal pelvic fascia) (deep layer of triangular ligament).
f. Vesical layer of visceral pelvic fascia

(*c*) *Treatment of wound in bladder and parietes.*—A large rubber drainage tube (diameter ⅞ inch) is now introduced into the bladder, and fixed to one of the skin margins by a fishing-gut suture. This tube should be fenestrated, and, although projecting well into the cavity of the bladder, should on no account lie in the *prostatic cavity* or touch the trigone.

The wound in the bladder wall is best treated by passing a purse-string suture of catgut around its margins after Lembert's method, and this, when tied, draws up the margins of the opening around the drainage tube, and prevents leakage at the sides. The margins of the incision into the bladder should not be sutured to the inner borders of the recti, as this delays the closing of the suprapubic sinus. The upper portion of the abdominal incision is closed by two or three interrupted fishing-gut sutures, picking up skin, fascia, and rectus muscle, whilst the lower angle is left open, and a gauze drain carried down into the retro-pubic space.

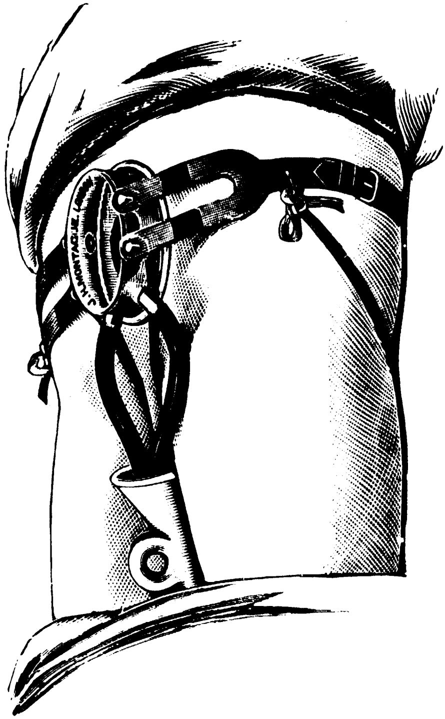

FIG. 218.—Suprapubic dressing, for use after suprapubic prostatectomy.—IRVING.

It is better, whenever possible, to proceed at once with the removal of the prostate when the bladder has been opened, but if severe cystitis is present, or there is reason to believe, either from a preliminary examination of the urine or from the patient's general condition, that the kidneys are in a precarious state, it is wise to defer the completion of the operation for a short time. In these circumstances a large drainage tube should be inserted, the bladder irrigated twice or three times daily, and a secondary prostatectomy performed a week or ten days later.

(*d*) *After-treatment.*—The patient having been returned to bed, the upper end of the drainage tube, which should project just beyond the dressings and bandage, is joined by a bent glass connection to a narrower tube draining into a covered glass receptacle.

At the end of a period of 48 to 56 hours, by which time the urine escaping is merely tinged with blood, this drainage tube is removed, and the patient can then be fitted with an Irving's suprapubic dressing (Fig. 218). Up to the time urine begins to pass naturally (10 to 21 days), the bladder should be washed out twice daily with warm boracic solution through a soft rubber catheter introduced above the pubes. Great care should be taken that a fall of not more than 6 inches is employed, to avoid all risk of distension of the prostatic cavity, and the liability to recurrent hæmorrhage.

II. Perineal prostatectomy.—*Special instruments.*—Retractors, prostatic tractor (Young's), bladder staff grooved on its inferior aspect, and perineal drainage tube.

Position.—The patient is placed in the lithotomy position, with a small sandbag under the buttock, so that the perineum looks considerably forwards. The surgeon sits facing the perineum, with an assistant on either side of him.

Operation.—Perineal prostatectomy may be divided into the following stages, namely :—

(*a*) *Parietal incision.*—A transverse semilunar incision 5 to 6 inches long is made in the perineum, the upturned extremities being directed forwards ; the centre of the incision lies at the junction of the posterior and middle thirds of a line drawn from the posterior attachment of the scrotum to the anus, and its length depends upon the width of the ischio-rectal fossæ and the fatness of the patient. The attachment of the transversus perinei and the bulbo-cavernosus (ejaculator urinæ) muscles, in front, is now separated from that of the external sphincter ani, behind, by a transverse cut through the central tendon of the perineum, so as to free the anterior wall of the rectum and allow it to be pushed backwards. Two retractors having been inserted so as to open up the wound, and at the same time to carry forwards the perinei muscles with the base of the progenital diaphragm (triangular ligament), the anterior margins of the levatores ani are sought for and separated. If sufficient exposure cannot be obtained by this means the muscles should be cut across.

(*b*) *Exposure of the prostate.*—The grooved staff is now passed into the bladder through the penis, its handle is depressed towards the abdomen and held accurately in the median plane by an assistant. This having been done, the wound is gradually deepened by blunt dissection until the staff passing into the apex of the prostate is identified. The greatest care is exercised here and during the subsequent steps of the operation to protect the anterior wall of the rectum from injury. The urethra is now opened by cutting through the apex of the gland on to the grooved staff well above the compressor urethræ membranaceæ, the margins of the urethral incision are picked up and held apart by a couple of lateral sutures, and the staff removed. Through the opening thus made a Young's prostatic tractor (Fig. 219) is passed into the bladder, and its blades separated so that they lie laterally. The assistant pulls the instrument well down, and at the same time carries the handle forwards, so as to bring the posterior aspect of the prostatic sheath into view, and with the finger the tissue in the recto-prostatic space is broken down until this aspect of the gland is well cleared.

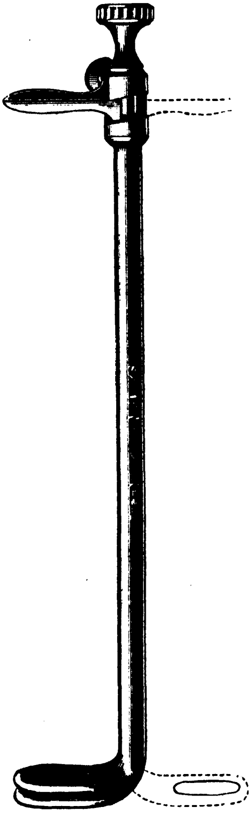

FIG. 219.—Young's prostatic tractor.

(*c*) *Removal of the prostate.*—Before proceeding further, the anterior rectal wall is packed off with a strip of gauze, and pushed well backwards into the hollow of the sacrum. The operator, seeing exactly what he is doing, then cuts into the prostate by a median vertical incision on its posterior aspect. This incision should be carried through the prostatic sheath, and well into the *pathological capsule.* If encapsuled adenomata are present these can then be readily enucleated with the finger and removed, but if the non-encapsuled variety ("fibrous prostate") is being dealt with this is more difficult to carry out. In the latter case as much of the gland as possible must be removed by a process of tearing with the finger, the operator making use of a pair of blunt-pointed scissors where this is impossible. As a rule, the prostate cannot be removed cleanly as in enucleation, and the operation has often to be completed *morcellement,* the prostatic tissue coming away piecemeal.

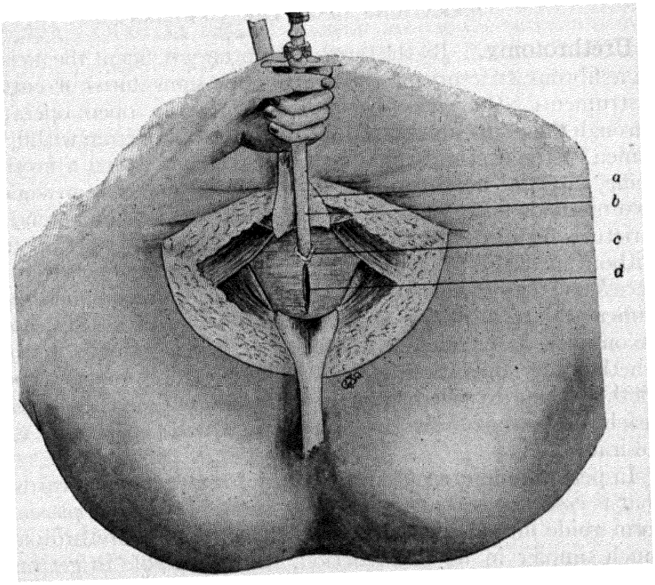

FIG. 220.—Perineal prostatectomy.

a. Retractor.
b. Prostatic tractor.
c. Opening for prostatic tractor.
d. Incision in prostate.

(*d*) *Treatment of perineal wound.*—The bladder having been irrigated, and all blood and débris removed from the wound, a short wide perineal drainage tube is inserted, so that one end projects just within the vesical cavity and the other beyond the skin incision, to one margin of which it is secured by a suture of salmon-gut. The somewhat large perineal wound is then lightly packed with gauze and dressings applied in the ordinary method, no attempt being made to suture the wound.

(*e*) *After-treatment.*—For the first few days after the operation the bladder is irrigated daily through the perineal tube, but the latter can usually be safely removed at the end of 5 to 7 days and the wound allowed to close. At this time a metal sound ($\frac{12}{14}$ E.) should be passed through the penis to secure the patency of the canal, and where much cutting and tearing has been necessary to effect removal of the prostate, it is wise to repeat this procedure at gradually increasing intervals, to prevent the formation of a traumatic stricture.

OPERATIONS UPON THE URETHRA

Urethrotomy.—By the term urethrotomy is meant the incision of a fibrous stricture of the urethra by some form of cutting instrument. This may be performed by an open operation through the perineum, **external urethrotomy,** or from within the lumen of the urethral canal by an instrument called a urethrotome, **internal urethrotomy.** In internal urethrotomy one of two methods is adopted, either the cut is made from behind the stricture forwards, or the division is effected by cutting from without inwards. In order to perform the former operation it is necessary that the strictured portion of the urethra be dilated sufficiently to admit a No. 4 E. catheter, and if this can be accomplished by gradual dilatation it is exceedingly doubtful whether any operation is really required. Moreover, if this method alone is relied upon it will place out of the surgeon's reach just that class of case in which operation is so desirable.

In performing internal urethrotomy from without inwards, all that is essential is that the operator should be able to pass a filiform guide into the bladder, and as this form of urethrotome is much simpler in its construction, and less liable to get out of order, it is the operation of choice in the majority of cases for which internal urethrotomy is necessary.

Indications.—(*a*) Stricture of the urethra in which gradual dilation is impossible, either—(i) because instrumentation occasions great pain and spasm, or is constantly followed by hæmorrhage or rigors; or (ii) because the stricture is either a resilient one or, on the other hand, is so hard that no impression can be made upon it.

(*b*) Acute retention of urine, when, after repeated suprapubic puncture and appropriate treatment, the stricture still remains impassable.

(*c*) Stricture of the urethra, complicated by urinary fistulæ or extravasation of urine.

(*d*) In some cases of stricture when time is an essential feature in the treatment.

Choice of operation.—The results of internal and external urethrotomy, if followed by careful and prolonged after-treatment, appear to be equally good, but in the former operation the period of convalescence is materially diminished, and the patient is spared the great inconvenience of a temporary perineal urinary fistula. Again, in stricture of the penile portion of the urethra a permanent fistula is almost certain to follow operation by the open method. Although the choice of operation will always depend to a certain extent on each individual surgeon's own experience, speaking generally, one may say that, except some special contra-indication is present, internal urethrotomy should be adopted.

External urethrotomy is specially called for under the following conditions :—

(*a*) Impassable stricture.

(*b*) Stricture complicated by urinary fistulæ or extravasation of urine, where perineal drainage is essential.

(*c*) Some cases of traumatic stricture, in which the urethra and perineum are involved in a fibrous cicatricial mass which is undilatable and beyond the reach of internal urethrotomy, and it is not considered desirable to excise the stricture by the method described on page 316–7.

(*d*) Septic infection of the urinary tract ; in these patients the large amount of absorption which takes place at the raw surface is exceedingly dangerous.

1. Internal urethrotomy.—*Special instruments.*—Urethrotome fitted with filiform guide (Walker's modification of Maisonneuve's instrument), bladder sound ($\frac{12}{14}$ E.), and well-varnished silk web catheter (No. 8 E.).

Position.—The patient is placed in the dorsal position with the buttocks slightly raised ; the surgeon stands on the patient's right, with his assistant opposite him.

Operation.—The urethrotome consists of three portions—the filiform guide, the staff, and the knife (Fig. 221). The staff, which is curved after the fashion of an ordinary bladder sound, somewhat resembles a probe-pointed director, and has a screw at its tip by which it can be connected with the filiform guide. The groove, which is only open externally as a narrow slit on the dorsal aspect of the instrument, ends at the bend in the staff, so that any risk of wounding the prostate or neck of the bladder is avoided.

The knife has a sharp edge in front and behind, and cuts up to No. 14 E., but its top is blunt, and this obviates the necessity of a shield.

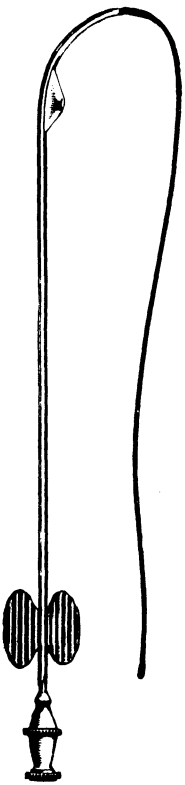

FIG. 221.—Urethrotome. Walker's modification of Maisonneuve's instrument.

The filiform guide is first of all passed into the bladder ; this can be done on the operating table whilst the patient is under the anæsthetic ; or, if it be preferred, time may be saved by introducing it on the morning of the day of operation. The staff is now screwed into the guide, and usually follows the latter through the stricture without difficulty. Having satisfied himself that the point of the director has entered the bladder, the operator holds it accurately in the median plane, inserts the knife into its groove, and then pushes it gently but firmly down the urethra until the stricture is encountered and divided. When the feeling of resistance disappears the blade should not be pushed on to the end of the groove, but should be immediately withdrawn. A metal bladder sound (No. $\frac{12}{14}$ E.) is now passed to make certain that the stricture is completely divided, a silk web catheter (No. 8 E.) tied in so that its tip just projects within the cavity of the bladder, and the patient returned to bed.

After-treatment.—The catheter is retained in position for from 3 to 8 days, and should not be withdrawn until it is felt to move quite freely backwards and forwards within the urethra. During this time the bladder is irrigated twice daily with boracic solution, and if necessary the catheter may be removed and replaced by one of similar make and size. Hæmorrhage may occur after the operation, in which case it is controlled by applying a firm pad to the perineum and exerting pressure on the intra-urethral catheter. The patient is confined to bed for 14 days, and at the end of this time a full-sized bougie is passed. It must be remembered that prolonged after-treatment of these cases is as important, if not more so, than the actual operation itself. The patient therefore should be kept under observation for two years or more, at the end of which time a fair proportion of cases will be completely cured. During the earlier part of this period a full-sized bougie should be passed once a fortnight, and if there is no tendency to contraction this period is lengthened up to one, and finally to three and six months.

2. External urethrotomy (Wheelhouse's operation).—*Special instruments.*—Clover's crutch, Wheelhouse's staff, long straight bistoury, probe-pointed gorget (Teale's), probe-pointed director, fine probes, silver catheters, "railroad" catheter.

Position.—The patient is placed in the lithotomy position, the legs being held apart by a Clover's crutch. The surgeon seats himself opposite the perineum, and his assistant stands on his left hand.

Operation. — Wheelhouse's staff (Fig. 223) is passed along the urethra until the extremity comes into contact with the stricture, the groove is turned towards the operator, and it is held in this position by an assistant.

An incision is made in the median raphé of the perineum, about 1½ or 2 inches long, and not extending nearer the anus than the anterior margin of the external sphincter (Fig. 224). This is deepened by cutting the fasciæ and the bulbocavernosus (ejaculator urinæ) muscle, until the groove in the staff is reached. The urethra is then opened in front of the stricture for about 1 inch, but care should be taken that the section of the urethral wall does not extend posteriorly beyond a point one-third of an inch from the stricture. The margins of the urethral incision are picked up with forceps, and a silk ligature passed through

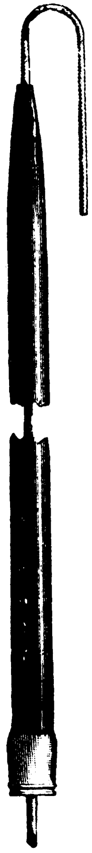

FIG. 222.—Railroad catheter.

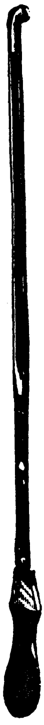

FIG. 223.—Wheelhouse's staff for external urethrotomy.

each side. These ligatures are left long and not tied, the ends being given to assistants to hold; they serve as retractors. Next, the staff is slightly withdrawn and half turned round, so that the hook on the tip is brought into the upper angle of the wound. By these means the incision in the urethra is held open at three points—laterally and at the upper extremity. The probe-pointed director is now taken and the proximal portion of the urethral canal sought for. Often this can be easily seen, but occasionally considerable difficulty is experienced in finding it. In such cases pressure may be made on the bladder from the suprapubic region, in the hope that urine will be expressed, or, failing this, the finger of an assistant should be passed into the rectum, and pressure exerted upon the vesiculæ seminales, and seminal fluid forced onwards.

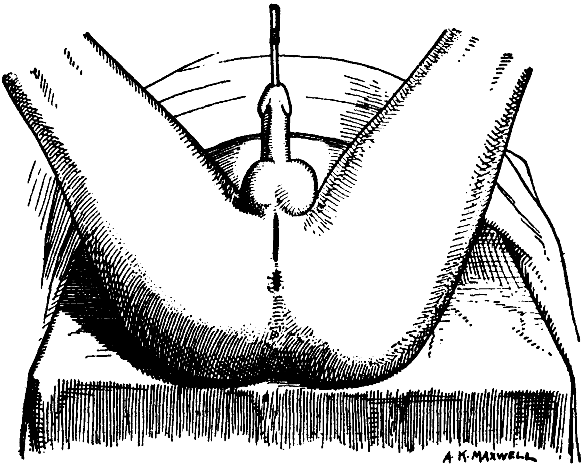

FIG. 224.—External urethrotomy (Wheelhouse's operation). Position of patient and external incision.

The aperture having been found by one of these methods, the probe-pointed director is passed through it into the urethra beyond the stricture and thence into the bladder. The groove of the director is turned towards the surgeon, and the stricture divided with a fine scalpel or a sharp-pointed bistoury. When the stricture has been divided the groove in the director is turned away from the surgeon, and the probe-pointed gorget (Fig. 225) passed along this groove until the cavity of the bladder has been reached, which is known by a sudden escape of urine.

The staff is removed, and the part of the urethra in front of the incision examined for fibrous bands, and if any are found they are divided. Next, a full-sized "railroad" silk web catheter (No. 12 E.) (Fig. 222) is passed along the urethra from the meatus to the perineal incision, and then along the gorget until it passes into the bladder. The gorget is withdrawn, and the catheter tied in the bladder.

The temporary ligatures are removed from the margins of the incision in the urethral canal, and the wound packed with strips of gauze, and a perineal bandage applied.

A tube should be fastened to the end of the catheter to convey the urine to a receptacle underneath the bed.

After-treatment.—The catheter should be left in for from four days to a week, and the perineal wound dressed daily. In most cases it is wise to change the catheter on the third or fourth day. When the catheter is changed a long catgut is passed through it into the bladder, and over this the old one is drawn out and the other introduced. Afterwards the catheter is not retained in position, but a full-sized one is passed each day until the external wound has closed.

A catheter ought to be passed regularly for several months, or even longer, after the perineal wound has healed, so as to prevent the recurrence of the stricture.

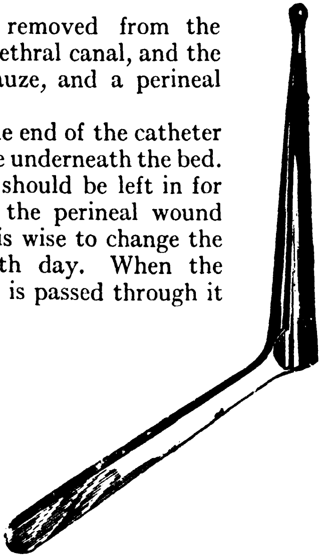

FIG. 225.—Teale's probe-pointed gorget.

Treatment of rupture of the urethra.—An operation is requisite in all cases in which the urethra is torn across or completely ruptured, and also in cases of partial rupture in which either a catheter cannot be passed into the bladder, or there is considerable hæmorrhage and bruising of the tissues of the perineum.

Special instruments.—Straight sound, probe-pointed director, Teale's gorget, full-sized catheters.

Position.—As in external urethrotomy.

Operation.—A grooved straight staff is passed along the urethra as far as it will readily go, and the extremity made to protrude towards the perineum. (The seat of the rupture in the great majority of cases is immediately in front of or at the perineal aspect of the uro-genital diaphragm (triangular ligament). With a scalpel the tissues are divided in the middle line of the perineum, until the groove of the staff is exposed. The urethra is then divided on the ventral aspect along this groove until the position of the rupture becomes apparent. The external wound is generally 1½ to 2 inches long, and terminates ½ inch in front of the anus. When this has been done, all extravasated blood and clots are, as far as possible, turned out of the wound, and any bleeding vessels picked up with pressure forceps and ligatured. The ends of the ruptured urethra are now sought for. The distal end is readily found by examining the end of the staff which passes through it. The proximal end can often be seen as a small bleeding prominence. Careful sponging and a good light are essential requisites in the search for the end of the torn urethra, especially when the injury is near the progenital diaphragm (triangular ligament). When found, a large silk web catheter should be passed through the meatus into the wound, and thence along the proximal part of the urethra into the bladder. Next, if possible, the margins of the torn tube are brought into apposition and fixed by careful suturing with fine chromicised catgut sutures. In the vast majority of cases this cannot be done, owing to the difficulty in finding and bringing the torn margins into apposition. The external wound is left completely open, and is lightly packed with gauze. When no catheter can be passed into the bladder it may be necessary, for the first few days, in order to evacuate the urine from a distended bladder, to aspirate this viscus above the pubes. This, however, should not be done until after the failure of other methods. Even in the favourable cases in which it is possible to unite the margins of the torn urethra, it must be remembered that it is necessary to continue catheterisation for a long period, otherwise a severed form of traumatic stricture may result.

Excision of a urethral stricture.—*Indications.*—Single strictures of the urethra when situated in front of the inferior layer of the uro-genital diaphragm, and very hard or cartilaginous in consistency, can be treated by removal of the affected segment of the urinary canal and union of the two divided ends. This operation is most suitable for a single stricture which has resulted from severe traumatism, and is not associated with a septic condition of the adjacent tissues.

Position.—The patient is placed in the lithotomy position, the surgeon sits opposite the perineum and the assistant on his left.

Operation.—The region of the perineum is palpated in order to determine the locality of the narrowed portion of the urethral canal, and a straight metal sound or Wheelhouse staff passed along the urethra until it reaches the stricture. The extremity of the sound is next made to project towards the perineum and then an incision is made along the perineal raphé about two inches in length. This is deepened until the corpus spongiosum is exposed upon the point of the sound and just in front of the stricture. By careful dissection with the scalpel the portions of corpus spongiosum containing the stricture, and proximal and distal to it, are separated from the adjacent structures. Usually the extent of the strictured portion of the urethra can be detected by the hard fibrous feel. Next the metal sound is removed from the urethra and the corpus spongiosum divided transversely through sound tissue on each side of the narrowed portion by cutting with a sharp scalpel. The divided ends of the urethral canal are dissected free from the surrounding tissues until they can be easily brought together in close approximation without exerting undue tension. The approximated ends are now united by the insertion of a series of sutures of fine chromicised catgut. The insertion of these sutures commences at the dorsum, and each suture passes through the entire thickness of the corpus spongiosum. When the sutures are tied, great care should be taken to bring into exact apposition the cut margins of the urethral mucous membrane. After the first few sutures have been introduced on the dorsal portion of the canal, a gum elastic bougie is passed along the urethra into the bladder. This will serve as an internal support and facilitate accurate suturing. When the circle of sutures has been completed the bougie is removed and the tissues of the perineum superficial to the sutured urethra joined together by the insertion of a few buried catgut sutures. Finally, the margins of the skin wound are united by interrupted sutures of salmon-gut. During the operation particular attention should be directed to the arrest of hæmorrhage, every small bleeding point being picked up and ligatured. If this is not done a hæmatoma is prone to form, which will delay union and jeopardise the result of the operation. When the operation has been completed a soft No. 12 red rubber is passed along the urethra into the bladder and tied in. Some surgeons advise that a suprapubic cystotomy should also be performed and the bladder drained suprapubically. In my opinion, however, this is not generally necessary.

Results.—Satisfactory results have been obtained in a fair percentage of urethral strictures treated by this method, and recurrence is much less liable to occur than in cases treated by either internal or external urethrotomy.

CHAPTER X

OPERATIONS UPON THE MALE ORGANS OF GENERATION

OPERATIONS UPON THE PENIS—
- Circumcision.
- Amputation of the penis :
  - (*a*) Partial.
  - (*b*) Complete.

OPERATIONS UPON THE TESTICLE—
- Castration.
- Radical cure of hydrocele.

OPERATIONS UPON THE SPERMATIC CORD—
- Varicocele.

OPERATIONS UPON THE PENIS

Circumcision.—Circumcision or removal of the male prepuce is necessary in many cases of phimosis ; it facilitates the treatment of certain venereal conditions, and is often advisable in patients who have a congenitally long prepuce, which allows the preputial secretion to collect underneath it and become a source of irritation.

Position.—The patient is anæsthetised, placed in the dorsal posture, and the genital region well exposed. The surgeon may stand on either side of the patient, and his assistant opposite to him.

Operation.—The prepuce is drawn slightly forwards, and then seized with a pair of dressing forceps immediately in front of the corona glandis. The blades are held in a sloping direction, so that considerably more prepuce is beyond the forceps on the dorsal aspect than on the ventral. The blades are closed, the glans penis slipping backwards, and the part of the prepuce which is distal to the forceps removed with sharp scissors (Fig. 226).

The mucous surface of the prepuce is now completely separated from the glans by peeling it backwards with the finger or a probe, and is cut away with scissors to within a quarter of an inch or less of the corona glandis. The skin of the prepuce is next trimmed with scissors if necessary, care being taken to leave the skin pointed immediately underneath the attachment of the frenum. All bleeding is arrested by ligature, and the free margin of the skin united to that of the mucous membrane just beyond the corona glandis by the insertion of a series of interrupted sutures of fine catgut (Fig. 227). The organ is washed with saline solution, thoroughly dried, and then the line of incision is covered with a thin strip of gauze and painted with collodion.

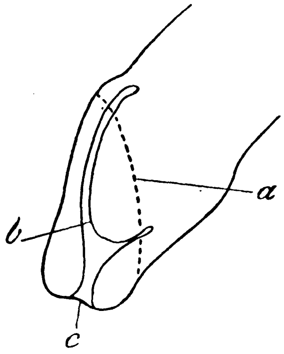

FIG. 226.—Circumcision. Penis showing phimosis.

a. Line of application of dressing forceps when prepuce has been drawn forward.
b. Extremity of glans penis.
c. Aperture of prepuce.

At the expiration of five days to a week this dressing can be taken off and the patient placed in a warm bath. A lint dressing with a small quantity of boracic ointment is then applied, and replaced daily until the wound has completely healed.

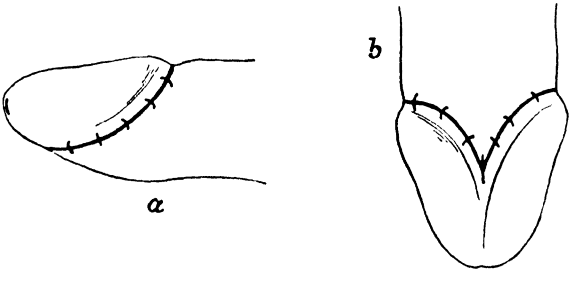

FIG. 227.—Circumcision. Appearance of penis when prepuce has been removed, and margins of incision united with sutures.

a. From lateral aspect.
b. From ventral aspect, showing method of suturing at frenum.

Amputation of the penis.—Amputation of the penis may be either partial or complete; in the former case a portion of the dependent organ is removed, and in the latter the entire structure, including the crura, is taken away.

Indications for operation.—The operation is rendered necessary in certain cases of epithelioma of the penis, in which it is possible to remove the entire diseased tissue, and very occasionally in gangrene of the organ, induced by constriction of rings and other bodies.

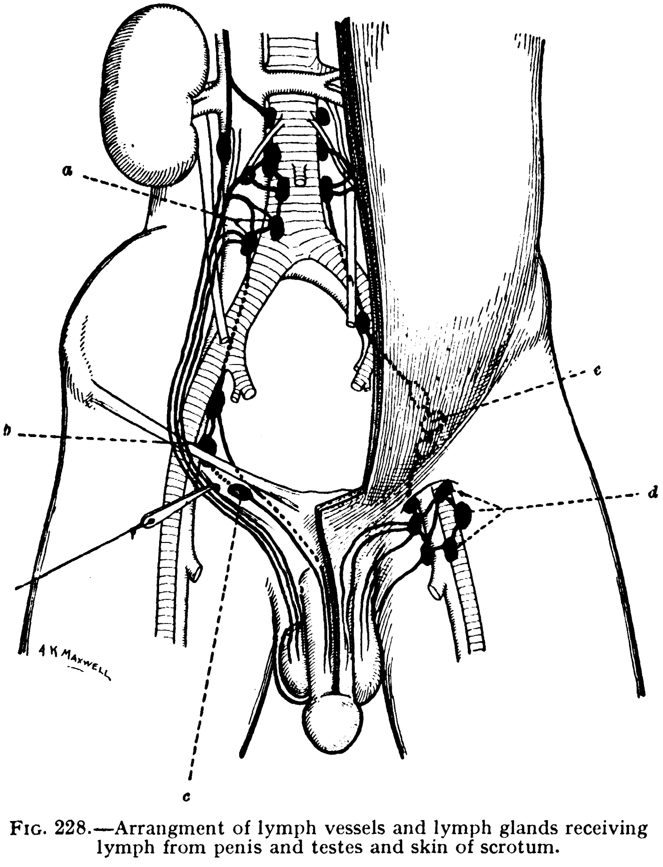

FIG. 228.—Arrangment of lymph vessels and lymph glands receiving lymph from penis and testes and skin of scrotum.

a. Lateral aortic lymph glands.
b. External iliac lymph glands.
c. Deep inguinal lymph glands.
d. Superficial inguinal lymph glands.
e. External iliac lymph glands

Partial amputation of the penis.—The dependent portion of the penis may be amputated at any point between the posterior portion of the glans and the junction of the organ with the scrotum.

Many methods of removing a portion of the penis have been adopted by different surgeons, but one which is easy to perform, and in addition gives excellent results, is known as the "flap" operation. This is the one which is now described.

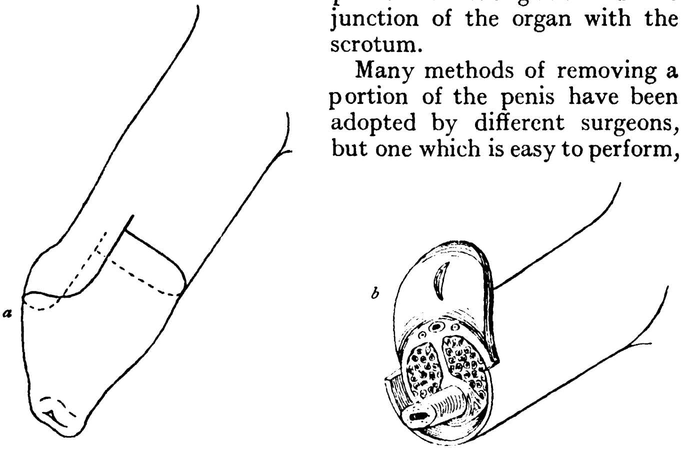

FIG. 229.—Amputation of part of penis.
a. Lines of skin incisions in formation of flaps.
b. Appearance of stump when part to be amputated has been removed.

Special instruments.—Long narrow-bladed knife, fine-toothed forceps, No. 12 E. gum-elastic catheter, sharp hooks, and elastic rubber tube.

Position.—The patient lies on his back near the right side of the operation table, with his thighs slightly separated; the operator stands on the right side, and the assistant opposite to him.

Operation.—An elastic ligature is placed around the root of the penis, so as to avoid hæmorrhage. The plane of the penis at which it is wished to effect the separation is decided upon, and then a dorsal skin flap is marked out and dissected back.

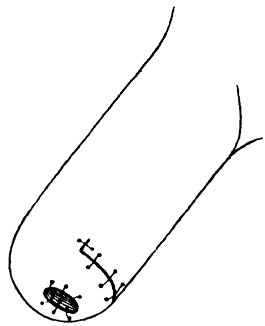

FIG. 230.—Amputation of part of penis. Operation completed.

The breadth of this flap should be equal to half the circumference of the organ, and its length to rather more than one diameter (Fig. 229). A ventral flap is then fashioned in a similar manner, but only a quarter of the length of the dorsal, and dissected back as far as the line of section. The gum-elastic catheter is passed along the urethra, and then the long narrow-bladed scalpel made to transfix the body of the penis between the corpus spongiosum and the corpus cavernosum, immediately anterior to the bases of the skin flaps. The catheter is removed, and the corpus spongiosum with the urethra divided about ½ inch in front of the posterior part of the incision. The corpus cavernosum is next divided on a level with the bases of the skin flaps, and all bleeding vessels tied. The arteries which require ligature are—the two dorsal arteries, on the dorsal surface between the halves of the corpus cavernosum; the arteries to the corpus cavernosum in the substance of this structure; and a branch of the artery to the bulb in the corpus spongiosum. The elastic ligature placed around the base of the penis is slightly relaxed, so as to make evident the position of these blood vessels. Any other bleeding points are ligatured, and then a small vertical incision, ½ inch in length, is made in the middle of the dorsal flap. The projecting portion of the corpus spongiosum is brought through this aperture, split vertically on both dorsal and ventral aspects for a short distance, and the two pieces sutured to the margins of the aperture by curved needles threaded with fine catgut. The edges of the dorsal and ventral flaps are brought into apposition, and fixed by the insertion of a row of fishing-gut sutures. The operation is now completed by the application of a collodion dressing to the lines of suture, and, as a rule, the retention of a catheter is not necessary after the performance of this form of operation. Contraction of the new meatus does not occur so commonly after this as after some of the other methods of amputation.

Complete amputation of the penis.—This operation comprises the removal of the entire penis, together with the crura. It has been called Thiersch's, and also Gould's operation.

Indications.—Carcinoma of the penis, with infiltration of one or both corpora cavernosa by growth.

Special instruments.—These are the same as those required for the previous operation, with the addition of a rugine or a periosteal elevator.

Position.—The patient is placed in the lithotomy position, the buttocks projecting slightly over the end of the operation table; the operator stands opposite the perineum of the patient, and the assistant on his left side.

Operation.—The operation may be divided into the following stages, namely—(*a*) Skin incision; (*b*) splitting the scrotum; (*c*) division and separation of the bulbous portion of the corpus spongiosum; (*d*) removal of the remaining portion of the penis, including the crura; (*e*) fixation of the proximal portion of the corpus spongiosum into the posterior angle of the incision, and closure of the remaining part of the external wound.

(*a*) *Skin incision.*—An incision is made with the scalpel which commences on the pubic eminence immediately above the dorsal aspect of the root of the penis, extends round the penis to its ventral aspect, and then backwards along the median raphé of the scrotum as far as the anterior part of the perineum.

This incision is racket-shaped, and it divides the skin and fasciæ.

(*b*) *Splitting the scrotum.*—With the fingers and the scalpel the scrotum is divided into two lateral halves, until the ventral aspect of the corpus spongiosum is reached. The gum elastic catheter is next passed into the urethra as far as the anterior layer of the triangular ligament.

(*c*) *Division of the corpus spongiosum, and separation of the proximal portion.*—A long narrow-bladed scalpel is inserted transversely between the corpus spongiosum and the crus a little in front of the bulb. The catheter is withdrawn and the knife made to cut outwards and divide the corpus spongiosum not quite half an inch in front of the bulb, a point which is beyond the termination of the ducts of Cowper's glands. When this has been done the proximal portion of the corpus spongiosum is seized with toothed forceps and dissected free from the crura as far back as the urogenital diaphragm (triangular ligament).

(*d*) *Separation and removal of the remaining portion of the penis.*—The surgeon then grasps the body of the penis with the left hand, and, taking the scalpel in his right, divides the suspensory ligament and other fibrous tissues which fix the organ to the adjacent structures. When the attachments of the crura to the ischio-pubic rami have been exposed, the scalpel is laid aside, and the margins of the posterior portion of the wound retracted. The rugine is taken, and with it the crura are separated from their bony attachments, and the organ removed. Four arteries require ligature—the two dorsal arteries of the penis, which will be found immediately underneath the pubic arch, and the arteries to the corpus cavernosum, which come through the urogenital diaphragm (triangular ligament) close to the attachments of the crura to the bone. These vessels are secured and ligatured, together with any other bleeding points which may become apparent.

(*e*) *Fixation of the proximal portion of the corpus spongiosum, and closure of the external wound.*—The remaining piece of the corpus spongiosum is seized with toothed forceps and slit for ½ inch along its dorsal and ventral aspects, and then the flaps so made are united to the margins of the posterior part of the incision by the insertion of fine catgut sutures. The anterior part of the incision is well sponged out, the two halves of the scrotum brought together, and the margins closely united with salmon-gut sutures; a drainage tube is passed into the deeper part of the wound on account of the oozing of blood, which usually goes on for a short time after the operation. It is not necessary to retain a catheter in the urethra.

The superficial inguinal lymph glands which receive lymph vessels from the skin of the penis should be removed in all cases of carcinoma of the penis which are submitted to amputation.

OPERATIONS UPON THE TESTIS

Castration.—Removal of both testes is called castration, but either one or both organs may be removed, according to the nature of the affection from which the patient is suffering.

Indications for operation.—Removal of the testis is indicated under the following conditions:—

(*a*) In early cases of malignant disease of the organ, or in those patients in whom a large, heavy growth is a great source of inconvenience.

(*b*) In cases of unilateral tuberculous mischief, in which the disease has not spread to the vesiculæ seminales and bladder, and the ductus (vas) deferens is not extensively involved.

(*c*) In some cases of imperfect descent of the testicle.

(*d*) In some cases of torsion of the testicle where the organ is gangrenous or imperfectly descended.

Special instruments. — Clamp forceps (for holding the stump).

Position.—The patient is placed in the dorsal posture with the legs extended and the thighs slightly separated ; the surgeon stands on that side of the patient which is to be operated upon, and the assistant on the opposite side.

Operation.—An incision is made which commences above, a short distance below the subcutaneous inguinal (external abdominal) ring of the affected side, and extends downwards on the lateral aspect of the scrotum towards its inferior border. This is made to extend through the tissues of the scrotum until the coverings of the spermatic cord and the testis with the tunica vaginalis are fully exposed. In cases of malignant disease of the testis, it is advisable to prolong this incision upwards and outwards to the region of the abdominal inguinal (internal abdominal) ring, and remove also that portion of the cord occupying the inguinal canal. The spermatic cord is clearly defined, and a clamp placed upon its coverings on each side immediately below the subcutaneous inguinal ring; an aneurysm needle is passed through the cord below the level of the clamps, and a double ligature inserted. Each half of the cord is tied separately, and one ligature is made to surround the entire structure. The cord is then divided a short distance below the application of the ligature, and the distal portion together with the testis and its tunica vaginalis removed. All bleeding points are ligatured, and then the clamps on the spermatic cord are removed, and if any of the arteries bleed they are picked up with artery forceps and tied separately. When all hæmorrhage has been arrested, the stump is pushed into the inguinal canal, and the external wound is closed by the insertion of a series of interrupted sutures. Some surgeons advise that the vessels of the spermatic cord should be tied separately, each one being picked up with artery forceps ; this is, however, not usually necessary. Under these circumstances a circular ligature is not placed around the entire cord, but the method of transfixion is the easier and safer one.

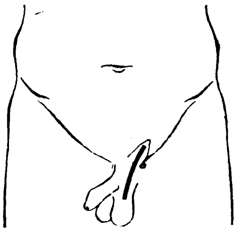

Fig. 231.—Removal of testis. External incision.

Extensive operations for carcinoma or sarcoma of the testis have been carried out, the object being complete removal of the testis and its coverings, the duct of the testis as far as the pelvic brim, the lymph channels from the testis to the lumbar lymph glands, and also those lumbar lymph glands which receive the testicular lymph vessels. This operation is conducted by prolonging the incision upwards and outwards towards the loin and lifting up the peritoneum. The success which has followed these extensive procedures up to the present scarcely appears to justify the recommendation of such severe operations. Usually, however, the patients so treated have been in an advanced stage of disease. Well selected and earlier cases may show more satisfactory results.

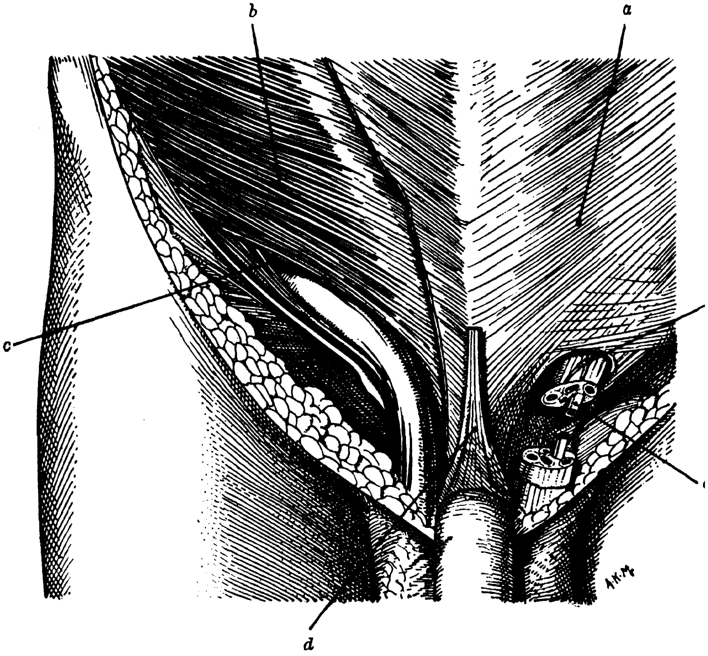

FIG. 232.—Dissection of inguinal regions, showing structures met with in an operation in the inguinal region.

a. External oblique.
b. Internal oblique.
c. Position of internal abdominal ring.
d. Suspensory ligament of penis.
e. Ductus (vas) deferens.
f. Spermatic cord.

Radical cure of hydrocele.—The operation for the radical cure of a hydrocele involves the removal by dissection of the parietal layer of the tunica vaginalis testis.

Indications.—A radical cure of a hydrocele ought to be performed in all cases in which the sac wall is very thick, and in those in which the fluid re-accumulates very quickly after tapping. Hæmatoceles also are best treated by incision, turning out the clot, and removing the thickened parietal layer of the tunica vaginalis.

Position.—The patient is placed in the dorsal position, with the thighs slightly separated, and a pillow of suitable size placed underneath the scrotum in order to raise it ; the surgeon stands on the affected side, and his assistant opposite.

Operation.—The scrotum being made tense by the assistant, an incision is made on the lateral aspect of the affected side. This incision extends for about two-thirds of the entire length of the swelling caused by the hydrocele.

The skin, superficial fascia, and dartos muscle are divided, and the fascial coverings of the swelling incised by repeated light strokes of the knife until the tense bluish-looking sac of the hydrocele comes into view. Several small superficial veins will be met with in this part of the operation, and should be clamped in two places before cutting, otherwise their divided ends will disappear amidst the loose scrotal tissues and give rise to troublesome oozing later. The sac of the hydrocele is now isolated from its fibrous coverings, over the greater part of its surface, by sweeping the handle of the knife or some form of flattened instrument around it, and when this has been done the swelling is opened and the fluid allowed to escape. The cut edges of the collapsed sac are then seized with pressure forceps, and after a little further blunt dissection the testis with the whole of its tunica vaginalis can be delivered through the wound. The thickened parietal layer of the tunica vaginalis is cut away with scissors a short distance from its reflection on to the epididymis. All bleeding points are now secured, and the testicle then replaced in the scrotum. Ordinary ligatures on the small vessels in the cut edges of the sac are extremely liable to slip, and it is better to transfix the membrane with a curved needle and fine silk, and tie them off in this way. A small rubber drainage tube is placed in the upper angle of the incision, and the latter closed by interrupted sutures in the ordinary manner. A drainage tube should be inserted in every case, but it can be removed at the expiration of 24 hours ; by its use all risk of a hæmatoma is avoided, and a means of exit provided for the small amount of blood and serous exudation which always occurs.

In some cases where the hydrocele has a comparatively thin wall or extends upwards towards the region of the base of the scrotum and external abdominal ring, it will be found more convenient to make an incision somewhat higher than the one given above. This incision should commence over the central portion of the pubic crest or at the pubic spine, and extend downwards on the lateral aspect of the scrotum for 1 inch or 1½ inches, as the case may require.

OPERATIONS UPON THE SPERMATIC CORD

Varicocele.—The blood is collected and carried away from the testicle by an abundant plexus of veins, the pampiniform plexus ; these vessels are grouped around the spermatic artery, and are massed mainly on the anterior aspect of the cord. A short distance below the subcutaneous inguinal (external abdominal) ring this plexus resolves itself into three collecting trunks, which pass up the inguinal canal, two in front of the cord and one behind, and end by forming the two venæ comites of the spermatic artery. The venæ comites join to form a single trunk just below their termination, and in the case of the right one a valve of two segments will be found guarding its opening into the inferior vena cava. With this exception the spermatic veins are devoid of valves, and those on the left side are exceedingly prone to become dilated and varicose, constituting the condition known as varicocele.

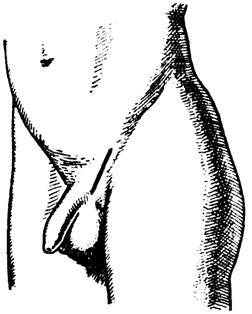

Fig. 233.—Scrotal operation for cure of varicocele. Line of skin incision.

Indications for operation.—The operation for the radical cure of varicocele is advisable under the following circumstances :—

(*a*) Those cases of varicocele in which the patient desires to enter one of the public services.

(*b*) Cases of varicocele in which a scrotal suspender and appropriate treatment have failed to relieve genuine pain, which is usually felt both in the lumbar region and in the testicle itself.

(*c*) Cases of inguinal varicocele in which either a hernial sac is actually present, or from the progressive weakening of the canal its appearance is only a matter of time.

Choice of operation.—A varicocele may be dealt with either through an incision in the neck of the scrotum, scrotal operation, or by ligature of the anterior two veins of the cord in the inguinal canal. The latter procedure should always be adopted in cases of inguinal varicocele, and possesses the additional advantages that the operation is performed in a region the skin of which is much more easily rendered "aseptic" than is possible in the wrinkled skin of even the neck of the scrotum; and, moreover, the hernial sac, if present, will be exposed, and can be removed at the same time. The only objection that can be raised against this form of operation is that the inguinal canal is weakened by the incision in the aponeurosis of the external oblique, a result which is very problematical in an aseptic case if the external oblique is efficiently sutured.

1. Scrotal operation.—*Position.*—The patient is placed in the dorsal position, with a pillow between the thighs. The surgeon stands on the affected side, with his assistant opposite him.

Operation.—An incision 1½ to 2 inches long is made in the long axis of the scrotum, commencing above over the subcutaneous inguinal (external abdominal) ring and just internal to the pubic spine (Fig. 233). The skin and fasciæ are divided and the spermatic cord laid bare. The anterior group (*i.e.* the majority) of the dilated veins are next separated from the surrounding structures for a distance of about 1½ to 2 inches or more, according to the length of the scrotum, and in doing this the ductus (vas) deferens and spermatic artery are identified. The later structures are held well out of the way by the assistant, and two ligatures passed around the separated veins, one at the upper and the other at the lower part of the incision. These ligatures are tied and cut short, the intervening portion of the veins removed, and their cut ends united by two or three interrupted sutures of fine silk. This can also be done by tying the two ends of the previous ligatures together; but besides producing a somewhat ungainly lump at the site of operation from overlapping of the cut ends, this also renders the ligatures more liable to slip. The external wound is closed without drainage by the insertion of three or four interrupted fishing-gut sutures.

2. Inguinal operation.—*Position.*—As in preceding operation.

Operation.—An incision 1½ to 2 inches in length is made, commencing just above and lateral to the pubic spine, and passing outwards and slightly upwards along the course of the inguinal canal. The skin, fasciæ, and aponeurosis of the external oblique having been divided, the canal is opened, and the cord exposed. The two anterior spermatic veins are then isolated, and dealt with exactly as in the scrotal operation. The incision is closed by two tiers of sutures: the first row, consisting of five or six interrupted sutures of fine silk, approximates the split fibres of the external oblique; the second tier of interrupted gut sutures brings together the skin margins.

CHAPTER XI

ABDOMINAL OPERATIONS UPON THE FEMALE ORGANS OF GENERATION

OPERATIONS ON THE OVARIES AND UTERINE APPENDAGES

Ovariotomy.—This operation consists in the removal of tumours of the ovary, broad ligament, and epoöphoron (parovarium), by an incision through the abdominal wall.

Indications.—

(*a*) Cystic disease of the ovary.

(*b*) Dermoid cyst of the ovary.

(*c*) Cysts in the broad ligament derived from the epoöphoron (parovarium).

(*d*) Solid tumours of the ovary, simple or malignant.

An ovarian tumour should be removed as soon as it is diagnosed. It is useless to wait for risks in connection with the tumour itself, or its effects upon neighbouring organs. It is, of course, possible that some cysts cannot be removed, either on account of their malignant character, or from extensive adhesions to important structures. An ovarian tumour is liable to inflammatory changes, torsion of the pedicle, rupture, and malignant changes.

Special Instruments.—Scissors (straight and angular), trocar and tubing for tapping the cyst, pedicle needle, and cyst forceps.

Position.—The patient is placed at first in the dorsal position, but the Trendelenburg (Fig. 86) or raised pelvic position is often of the greatest assistance. The surgeon stands on the right side of the patient, and the assistant directly opposite to him.

Operation.—(*a*) *Parietal incision and exposure of tumour.*—An incision 2 to 3 inches long (Fig. 234) is made in the middle line, between the umbilicus and the pubes, the lower extremity terminating a little above the upper limit of the mons veneris. The skin and fascial tissues are first divided, and the aponeurosis of the recti exposed. All bleeding is arrested with forceps. The interval between the recti and pyramidales is now sought for, and the muscles separated for the length of the incision. The fascia forming the posterior sheath of the rectus is exposed and divided, and the extra-peritoneal fat exposed. This varies much in thickness, and must be cut through with care, successive layers being lifted up with dissecting forceps before division. The parietal peritoneum is then exposed, and is picked up and divided in the same way. As soon as the peritoneum is opened, air enters, the intestines or cyst fall away, and the abdominal wall can be lifted up by the fingers. The peritoneum is then divided on two fingers for the length of the incision, care being taken below not to injure the bladder, which is often much displaced, and to avoid the veins which run in a vertical direction near the middle line.

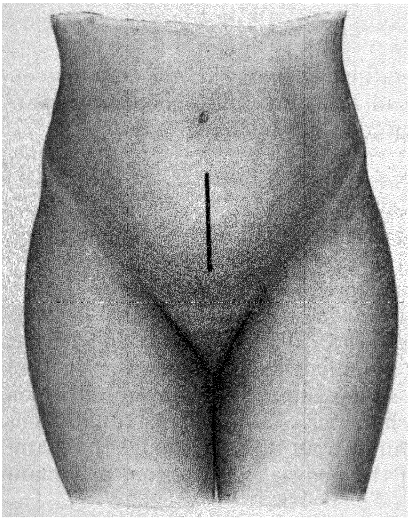
FIG. 234.—Ovariotomy.—Parietal incision.

In a simple case it is an easy matter to open the abdomen and to expose the glistening cyst; but if the peritoneum is thickened, or there are dense adhesions, it is sometimes difficult to decide when the cyst itself is reached. The incision may even be carried through the cyst wall.

In such cases it is better to open the peritoneal cavity higher up. After exposing the tumour, it should be carefully examined to ascertain if it be cystic or solid; and to discover the number and variety of adhesions (if any). The character of the tumour should also be determined, whether inflamed, dermoid, or malignant; and if there are secondary deposits elsewhere in malignant cases. It is much better not to *attempt* removal in hopeless cases, since nothing is gained by an unfinished ovariotomy.

(*b*) *Treatment of adhesions.*—If recent, these are easily sponged away or separated with the fingers. More serious adhesions in the case of large cysts should be dealt with after the cyst has been emptied. Portions of omentum may require ligature before division. Adhesions to the intestine need especial care; and if in separation of a piece of the cyst wall adhering to the bowel tearing or perforation occurs, all damage must be repaired by careful suturing.

Peritoneal adhesions to the rectum are often very troublesome, and the ureters or large pelvic veins may be damaged. The bladder may also be wounded if its limits are not borne in mind.

When the vermiform appendix is adherent to an ovarian cyst, or to the Tuba uterina (Fallopian tube) or broad ligament, it is better to remove the appendix than to separate and divide the adhesions and leave it behind.

(*c*) *Emptying the cyst.*—This is sometimes quite an easy matter, and it may be tapped by a trocar, the cyst being drawn out of the incision as the fluid is evacuated. Its contents should not be allowed to enter the abdominal cavity.

In some cases the fluid is very viscid, or the cyst is so multilocular that it cannot be emptied in this way. Dermoids contain hair and sebaceous material that will not run through a cannula, and when these are met with, the parietal incision should be enlarged upwards sufficiently to allow the entire cyst to be delivered whole. In multilocular cysts the secondary loculi may be broken down by the fingers by enlarging the opening into the cyst, or very thick material extracted by the hand.

Inflamed cysts of small size should be extracted whole, after enlarging the abdominal wound.

Some tumours necessitate enlargement of the abdominal wound, on account of their being almost entirely solid. It is always wiser in difficult cases to enlarge an abdominal wound than to work in darkness and uncertainty.

(*d*) *Treatment of pedicle and removal of tumour.*—When the cyst has collapsed and been drawn up out of the wound, or has been delivered whole, the pedicle has to be secured. This consists of the Tuba uterina (Fallopian tube) and the parts of the broad ligament containing the ovarian vessels and ovarian ligament.

Sometimes the pedicle is long and thin, and may be easily secured by transfixing it, at a point devoid of vessels, with a pedicle needle armed with silk or chromicised catgut of sufficient thickness. It is a mistake to use too thick a ligature in tying ovarian pedicles. The loop of silk or catgut is next divided and held, and the needle withdrawn. Two threads thus pass through the pedicle; these are interlocked and firmly tied, one on either side. The interlocking of the ligature loops prevents the pedicle splitting, and helps to avoid troublesome hæmorrhage.

The tumour is now cut away, leaving a stump of sufficient size not to slip through the ligature loops. The cut surface should be examined for any oozing before being dropped back into the abdomen. Large vessels in the stump may be ligatured again separately, for additional security. The opposite ovary should always be examined to see if it also is diseased. Small cysts in the periphery of an otherwise healthy ovary may be

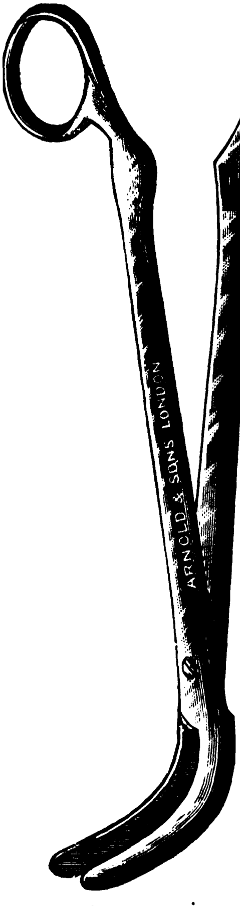

FIG. 235.—Ovariotomy. Cyst forceps.

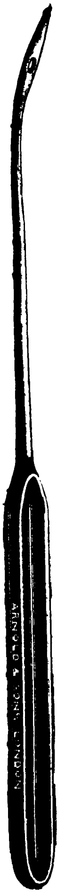

FIG. 236.—Ovariotomy. Pedicle needle.

excised by a wedge-shaped incision, and the cut surface closed by fine chromicised catgut. This is important, as it sometimes enables the operator to leave a piece of healthy ovary in a case where the other ovary *has* to be removed for hopeless cystic degeneration.

Large pedicles, and especially broad short pedicles, are sometimes very difficult to secure. They may need a second, or even a third, transfixion with looped interlocked ligatures. All knots should be securely tied, and loose ends avoided by cutting as near the knot as can be done with safety. Sometimes the pedicle is so short, and so dragged upon, and the cyst so large, that it is impossible to ligature the pedicle with safety before the main mass of the tumour has been cut away. In such cases the pedicle may be clamped for a time with large pedicle forceps (Fig. 235), the cyst removed, and then the pedicle held up and the ligatures passed by transfixion below the clamps.

As the clamps are gradually relaxed the ligatures are firmly tied. Slipping of the ligatures of an ovarian pedicle is a serious matter, and the pedicle should always be finally examined before closing the abdomen. If the ligatures have slipped, the pedicle must be retied below the seat of the original ligature.

After the ligatures have been tied, the peritoneum of the stump of the pedicle distal to the ligature should be dissected up, and then sewn over the surface of the cut pedicle by a continuous suture of catgut, in order to avoid the formation of adhesions afterwards.

Tumours of the broad ligament have no pedicle, and therefore cannot be drawn out of the abdominal wound. They should be enucleated. Enucleation is performed by dividing the capsule of peritoneum which can be moved over the cyst beneath. The capsule can often be recognised by the strands of unstriped muscular fibres which it contains. When the right layer is reached the whole tumour is easily shelled out. It may be tapped at once, or later, according to size.

The walls of the capsule often contain large blood vessels which must be ligatured. The capsule itself is dealt with by removing as much as possible, ligaturing the remainder, and finally closing the opening by a continuous or purse-string suture, after obliterating the deep portions of the cavity by inserting a number of buried sutures of catgut. If too large with deep connections, and the bleeding is troublesome, its edges may be secured to the margins of the abdominal wound, and its cavity drained, for twenty-four hours or more, with gauze.

False capsules, which are very puzzling, sometimes occur, covering and embedding an ovarian tumour. They mostly consist of peritoneal lymph and inflammatory adhesions, though it should be remembered that intra-ligamentous tumours sometimes burrow beneath and displace the peritoneum to an extraordinary extent. In performing enucleation, the bladder, ureters, rectum, pelvic colon, cæcum, vermiform appendix, or large blood vessels may be wounded.

(*e*) *Treatment of the peritoneum.*—The peritoneum should be cleansed of all blood-clot or any material that may have escaped during the operation, by sponging or washing out the cavity with warm saline solution. Care should be taken to guard against infection of the peritoneum in burst papillary cystomata, or by material which has escaped from suppurating, inflamed, or necrotic cysts.

(*f*) *Closure of the abdominal wound.*—This is closed by the insertion of three tiers of sutures. The peritoneum is first closed by a continuous suture of fine chromicised catgut. The sheaths of the recti are then approximated by interrupted sutures of chromicised catgut or silk; and lastly, the skin wound is closed with interrupted salmon-gut sutures. Drainage of the abdomen may be required after ovariotomy, when septic material has escaped into the peritoneal cavity, or when there is free oozing from divided or separated adhesions, but it is rarely requisite except in septic cases. Vaginal drainage may be established in some instances, when the bottom of the recto-uterine pouch is the seat of an abscess. In this case an incision is made through the posterior fornix of the vagina, and a rubber drainage tube introduced. The parietal wound is then completely sewn up, as above.

Removal of the uterine appendages.—Removal of the uterine appendages comprises several operations, to which distinctive names are given. Thus removal of the ovary is known as oöphorectomy. This may be complete or partial. In the latter case a segment of the ovary is removed and the operation called *resection of the ovary*. Salpingectomy, or removal of the Tuba uterina (Fallopian tube), may also be complete or partial, the latter being known as *resection of the Tuba uterina (Fallopian tube)*. Removal of both ovary and Tuba uterina (Fallopian tube), and a portion of the broad ligament, is called Salpingo-oöphorectomy, or often simply removal of the uterine appendages.

These operations, which formerly were discussed together, are best considered separately, since the indications for and the details of the operations are very different. Conservative surgery has here, as in many other regions, been found to be of great advantage.

Removal of the ovaries.—Oöphorectomy.—*Indications.*—Removal of the ovaries is indicated in the following conditions:—

(*a*) Some forms of chronic ovaritis, and abscess of the ovary.

(*b*) Hernia of the ovary; when an ovary forms part of the contents of a hernial sac it should be removed.

(*c*) Some forms of hæmatoma, or apoplexy of the ovary.

(*d*) In some cases of inoperable cancer of the breast. The results of the operation in inoperable cancer of the breast are very variable, but in women who have not passed the climacteric improvement or an apparent cure sometimes follows.

(*e*) In osteo-malacia. In a number of cases of this disease either recovery or marked improvement has followed removal of both ovaries.

(*f*) In some cases of marked stenosis of the vagina (either acquired or congenital) in which it is advisable to bring about cessation of the menstrual periods, and very undesirable that pregnancy should occur, and in which hysterectomy is considered inadvisable.

Oöphorectomy in the treatment of fibro-myomata of the uterus, and also in the treatment of dysmenorrhœa and various neurotic conditions, has practically been given up owing to the unsatisfactory character of the results. Fibro-myomata of the uterus are better treated by removal of the uterus and attached tumours and dysmenorrhœa and neurotic conditions by other measures.

Special instruments.—Pedicle needle and clamp forceps of medium size.

Position.—The patient is placed in the dorsal position, with the pelvis slightly raised. The surgeon stands on the right side of the patient, or when one ovary only is diseased on the affected side, and the assistant opposite to him.

Operation.—An incision is made 2 to 3 inches long in the middle line, below the umbilicus, and extending to immediately above the mons veneris. The skin and fasciæ are divided, and the interval between the recti recognised. The aponeurosis is incised, and the recto separated and pulled apart. The extra-peritoneal tissue is next cut through, and the peritoneum divided for the entire length of the incision.

The great omentum and the coils of intestine are pushed upwards and kept out of the way by packing the peritoneal cavity above and on each side of the incision with large flat gauze pads or sponges. The fingers are now passed downwards into the pelvis until the fundus of the uterus is reached, and then they are passed along the broad ligament until the ovary is felt. The ovary, with its Tuba uterina (Fallopian tube) and part of the broad ligament, are pulled upwards into the wound ; and a rubber-covered clamp is placed upon the infundibulo-pelvic ligament. The ligament of the ovary is grasped with a pair of forceps, and held by an assistant, who also compresses the ovarian artery. Next, the ovary is lifted up or pulled away from the broad ligament so as to form a pedicle at its hilum. This pedicle is transfixed with a blunt-pointed pedicle needle carrying a double ligature. The needle is withdrawn, the two ligatures locked and tied, and the ovary removed, by cutting away with scissors. If possible, the peritoneum of the stump is sewn over the cut surface, so as to avoid leaving a raw area, which might later assist in the formation of adhesions.

When a pedicle cannot readily be formed in the above manner, an oval incision is made around the ovary at its attachment to the broad ligament ; and it is cut away with scissors. All bleeding points are now picked up and ligatured, the clamps being loosed so as to ensure that no vessels are missed. The space from which the ovary was removed is obliterated by fixing its walls in apposition by the insertion of a few points of interrupted sutures. If troublesome hæmorrhage occurs, a ligature should be applied to the infundibulo-pelvic ligament in the outer part of the wound, so as to include the ovarian artery.

The margins of the peritoneal incision are united by a continous suture. The parts are sponged dry ; and a similar operation performed on the opposite side when both ovaries require removal. Finally, the protecting gauze pads and sponges are removed, the coils of intestine allowed to fall down into the pelvis, and the great omentum placed in front of them. The parietal wound is then closed by the insertion of three tiers of sutures in the usual manner.

Resection of the ovary.—Partial excision of the ovary, or resection, may be practised when the disease is definitely localised. The diseased ovary is brought into the abdominal wound, as in the previous operation, and rubber-covered clamps are placed on the broad ligament on each side of the ovary. A wedge-shaped incision, surrounding the diseased portion, is made with a scalpel into the ovary, and the affected part removed. Bleeding is arrested by ligature, and the surfaces of the wound brought together and fixed in apposition by the insertion of several interrupted sutures of chromicised catgut. The parts are sponged dry, the ovary dropped into the pelvis, and the parietal wound closed.

Salpingectomy.—*Indications.*—Removal of the Tuba uterina (Fallopian tube), or salpingectomy, is indicated in the following conditions:—

(*a*) Certain cases of inflammation of the Tuba uterina (Fallopian tube) or tubes following gonorrhœa or other septic condition.

(*b*) Pyosalpinx.

(*c*) Hydrosalpinx.

(*d*) Tubal pregnancy.

(*e*) Primary tumour of the Tuba uterina (Fallopian tube), such as papilloma and carcinoma.

(*f*) Some conditions in which it is desirable to sterilise the patient.

Often in cases of disease of the Tuba uterina (Fallopian tube) the corresponding ovary is also affected. Then it is desirable that both should be removed. These cases are discussed in the next section.

Special instruments and position.—As in the previous operation.

Operation.—The abdomen is opened, the intestines and great omentum packed away, and the pelvis investigated as in the previous operation. Often adhesions are met with and require to be either separated or divided. If recent, they should be separated by sponge pressure or with the fingers; and, if firm, they must be ligatured in two places with catgut, and divided. Adhesions to the rectum often give trouble, owing to both their position and extent. They should be fully exposed before separation or ligature. Sometimes careful dissection with the scalpel is necessary before the connections can be set free. When both Tubæ uterinæ (Fallopian tubes) are involved in adhesions and require removal, it is desirable to separate or divide all the adhesions on both sides before attempting this, because if one side is dealt with first, the ligatures which are applied may be loosened or slip during the manipulations necessary to free the adhesions on the other side.

When the tubes have been separated and all adhesions divided, one tube is lifted up into the abdominal wound, and the bottom of the pelvic cavity having been packed with one or more gauze sponges, removal is effected. The outer portion of the mesosalpinx is grasped by forceps, lifted up and cut away from its connections below with scissors until the uterus is reached, any bleeding vessels being picked up with pressure forceps. A small flap of uterine tissue anteriorly and posteriorly is turned back at the junction of the tube with the uterus, and the mucous membrane of the tube ligatured and cut through as it pierces the uterine wall. The stump of mucous membrane is cauterised with liquefied carbolic acid, and the two flaps of uterine tissue sutured over the stump. All bleeding points in the space from which the tube has been removed are ligatured with catgut, and then the anterior and posterior peritoneal margins of the broad ligament are joined together by inserting a continuous suture of chromicised catgut.

The tube on the opposite side is removed in a similar manner. Next, the parts are sponged dry, and all gauze pads and sponges removed from the pelvis and from the peritoneum cavity above. The operation is completed as in oöphorectomy.

Partial salpingectomy, or resection of the Tuba Uterina (Fallopian tube).—This operation may be performed for the removal of localised non-malignant tumours and cysts when they involve the outer portion of the tube. After the affected portion of the tube and the abdominal extremity have been excised, hæmorrhage is arrested by ligaturing the bleeding vessels, and next the mucous membrane, where the tube is cut across, is everted and stitched to the peritoneum of the broad ligament. The other incised portion of the broad ligament is sewn up as in the previous operation.

Salpingo-oöphorectomy. — Salpingo-ovariotomy — or removal of the uterine appendages.—*Indications*—

(*a*) Certain cases of inflammation, or suppuration of the Fallopian tubes, in which the corresponding ovary is also involved.

(*b*) Tuberculous diseases of the Tuba uterina (Fallopian tube) and ovary. In tuberculous disease of the uterine appendages the ovary and Tuba uterina (Fallopian tube) are usually both involved.

(*c*) Some cases of tubal pregnancy.

(*d*) Tubo-ovarian cyst or abscess.

(*e*) Carcinoma of the Tuba uterina (Fallopian tube).

Special instruments and position.—As for oöphorectomy.

Operation.—(*a*) *Parietal incision, exposure of appendages, and separation or division of adhesions.*—The abdomen is opened and the uterus and appendages are exposed as in oöphorectomy (p. 337). The Tuba uterina (Fallopian tube) and ovary of one side are freed from their abnormal connections (if any) with adjacent structures, by separation, or ligature and division of adhesions, and lifted up into the parietal wound. Then they are carefully examined, in order to determine the portions which require removal. Next, a similar procedure is carried out on the opposite side, after packing the space where adhesions have been separated or divided, with gauze sponges.

When determining the portions to be removed, it should be borne in mind that it is desirable to leave behind one ovary if the conditions will allow of this being done.

(*b*) *Removal of appendages.*—The ovary and tube of one side are lifted up into the wound, and the broad ligament below the ovary transfixed with a pedicle needle, armed with a double ligature of chromicised catgut, care being taken to avoid injury to large veins. The two ligatures are locked and tied, each surrounding one half of the pedicle, and pressure forceps placed on each side of the pedicle beyond the ligature. The ovary and tube are separated by cutting through the pedicle with scissors ½ inch beyond the seat of the ligatures, and removed. If possible, the peritoneum of the pedicle should be divided a little longer than the tissues in the interior. The surface of the pedicle stump is sponged, so as to make sure that all blood vessels have been occluded ; and then the peritoneum is sewn over the surface in order to avoid leaving a raw surface, which later might contract adhesions with adjacent viscera. The ligatures are cut short, the forceps removed, and the stump allowed to fall back into the pelvis. When there is much fibrous tissue around the tube and in the broad ligament, the result of previous inflammation, it is usually not possible to define a pedicle and transfix it in the manner just described. In this case, after the ovary and tube have been lifted up into the parietal wound, the outer portion of the broad ligament, or the infundibulo-pelvic ligament, is transfixed and ligatured so as to secure the ovarian artery, and the broad ligament close to the uterus treated in a similar manner, this second ligature surrounding the uterine (Fallopian) tube and the ligament of the ovary. The uterine (Fallopian) tube and ovary are then lifted up, and separated by cutting through the broad ligament with scissors. All bleeding points are picked up and ligatured, and the incised peritoneal margins of the broad ligament joined together by the insertion of a continuous suture of catgut.

The operation on one side having been completed, the parts are sponged dry, and protected with a flat gauze pad. Next a similar procedure is carried out on the opposite side.

(*c*) *Treatment of peritoneum and closure of external wound.*—The gauze pads and sponges are removed from the pelvis, and the parts carefully sponged with gauze sponges wrung out of hot saline solution. If oozing of blood still continues, careful search is made for any bleeding points, which when found are picked up and ligatured. When there is general oozing and no definite points can be seen irrigation of the pelvis with hot saline solution (110° to 115° F.) will usually succeed in arresting it.

Next, the protecting pads are removed, the intestines and omentum allowed to fall back towards the pelvis, and the parietal wound closed by sutures in the usual manner.

When suppurating cases are being dealt with, and the pus-containing tube has burst during the manipulations and caused contamination of the pelvic structures, it may be necessary to establish drainage. Often, however, this is not required, since in cases of considerable duration the pus is usually sterile. If drainage is considered desirable, it is generally best to leave the lower portion of the parietal wound unsutured, and to pass a large rubber drainage tube to the bottom of the recto-uterine pouch. The patient is in these cases afterwards nursed in the sitting position.

Abdominal Operations upon the Uterus

Removal of a fibro-myomatous uterus by abdominal section: Abdominal hysterectomy or abdominal hystero-myomectomy. — *Indications.* — Uterine fibro-myomata are removed for hæmorrhage, pressure symptoms, large size, rapid growth, or on account of complications. As a general rule, in the treatment of patients suffering from fibroids of the uterus, it may be stated that when the tumours are growing and distinctly increasing in size, when they are undergoing degeneration,—myxomatous, sarcomatous, or necrotic—and when they give rise to definite symptoms, they should be removed by a surgical operation, unless there are conditions which contra-indicate the performance of any severe operative procedure. It periodically happens, however, that fibroids of considerable size, and increasing, are discovered which do not cause symptoms, and the question arises, what course ought to be adopted concerning them? My own opinion is, that if there are no conditions or reasons against removal it is better to take them away, on account of the degenerations which may occur in them, and the complications to which they may give rise. Fibroid tumours in old and feeble women which are not giving rise to symptoms or increasing in size are best left alone.

Choice of variety of operation.—Two different forms of abdominal operation are available for the removal of fibro-myomata of the uterus; in one the uterus and attached fibroid tumours are excised, in which case the operation is known as hystero-myomectomy or simply hysterectomy ; and in the other the fibroid tumour or tumours are locally removed—the operation then being called myomectomy.

Hysterectomy (hystero-myomectomy) is the usual form of operation, since it is suitable for most cases of fibroids of the uterus ; and its performance is accompanied by less risk to the life of the patient than that of myomectomy. The latter operation is especially to be recommended when the patient is comparatively young—under thirty-five or thereabouts—when the tumours are sub-peritoneal and pedunculated, or there is only one, and it is desirable that the patient should be capable of having children. (Submucous fibroids are usually readily removed by the vaginal route.)

Hysterectomy (hystero-myomectomy) may be either partial or complete. In the former the uterus is divided through the cervix—supra-vaginal hysterectomy; and in the latter the vagina is opened and the entire uterus excised—pan-hysterectomy. The former operation is the one recommended for adoption in most cases, on account of the comparative ease of performance, the freedom from hæmorrhage, and the good results which follow : and the latter is reserved for the small number of cases where the cervix is the seat of disease.

Special instruments.—Large clamp forceps,—straight, curved, and angular,—volsellum forceps, aneurysm needle, and a blunt dissector.

Position.—The patient is placed in the dorsal position with the pelvic slightly raised. The surgeon stands on the right side, and the assistant on the left.

Operation. — Abdominal hysterectomy (hystero-myomectomy) may be divided into the following stages :—

(*a*) *Parietal incision, exposure, and delivery of the fibro-myomatous uterus.*—A vertical incision is made a little to one side of the middle line or in the middle line, 4 to 6 inches in length, according to the size of the uterus—and terminating below immediately above the mons veneris. The layers of the abdominal wall are cut through, and the peritoneal cavity opened. The great omentum and the coils of intestine which lie in front of the tumour and in the pelvis are pushed upwards and held there by packing with large gauze pads. The size, extent and connections of the tumour are ascertained, and adhesions sought for, ligatured in two places, and divided. Usually, however, there are few if any adhesions to surrounding viscera, unless there has been previous inflammation. The enlarged uterus is now grasped with the hand, or, if necessary, with a large pair of volsellum forceps, and forcibly drawn out through the parietal wound. Occasionally this is not possible until portions of the broad and round ligaments have been divided.

(*b*) *Ligature and division of the broad ligaments; exposure and ligature of the uterine arteries.*—The broad ligaments are ligatured in the following way. The one most easily dealt with is transfixed with a pedicle needle, armed with medium silk. This is done, if possible, on the uterine side of the ovary, which should not be removed. This ligature secures the ovarian artery. The uterine side of the broad ligament is clamped, and the tissue between this and the ligature divided. Sometimes the tension is so great that the knot cannot be securely tied till a portion of the broad ligament has been first divided. A second and even a third ligature is passed through the broad ligament lower down and firmly tied, the uterine portion being clamped with forceps.

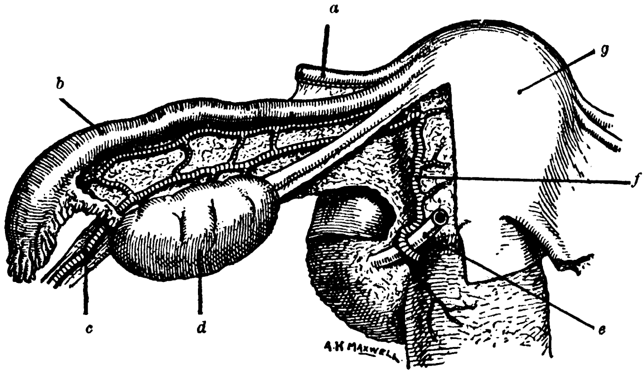

FIG. 237.—Position of uterine and ovarian arteries.—After KELLY.

a. Round ligament of uterus.
b. Uterine (Fallopian) tube.
c. Ovarian artery.
d. Left ovary.
e. Ureter.
f. Uterine artery.
g. Uterus.

The round ligament is generally included in one of these ligatures, but it may be wiser to tie it off separately, as it often contains a large vessel, and may be very tightly stretched over the tumour.

The opposite broad ligament is now treated in a similar way. The next step consists in the reflection of the flap of peritoneum and bladder from the front of the uterus. An incision is made across the front of the uterus, from side to side, about ½ inch above the line of attachment of the bladder. Its distal ends meet the incision in the broad ligaments. This flap is now carefully turned down with the bladder. If the proper cellular layer is reached this is an easy matter, but the peritoneum is sometimes very adherent to the front of a fibroid uterus, and needs careful dissection.

A simple peritoneal flap is next reflected from the posterior aspect of the uterus.

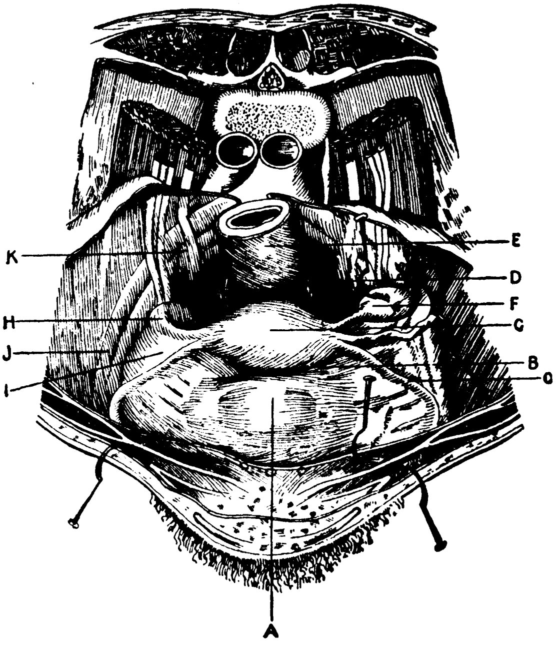

FIG. 238.—The viscera of the female pelvis, as they appear when seen from above and in front.—After TESTUT.

A. Fundus of bladder.
B. Utero-vesical pouch.
C. Uterus.
D. Pouch of Douglas.
E. Rectum.
F. Ovary.
G. Round ligament of uterus.
H. Uterine (Fallopian) tube.
I. Broad ligament.
J. External iliac vessels.
K. Hypogastric (internal iliac) vessels.

When the flaps have been turned down it is usually quite easy to see or define the position of the uterine arteries as they lie upon the lateral aspects of the cervix. A curved needle, threaded with silk, is passed beneath the artery on one side, and the vessel is securely tied. Forceps are applied above the ligature, and the artery divided between them and the ligature. If the artery has not been properly secured it spurts at once, but can be easily seized with forceps and tied. The opposite uterine artery is tied in a similar manner. Another method is to expose the artery by dissecting down on to it through the peritoneum, and ligaturing it at once in the earlier stage of the operation.

(*c*) *Division of cervix and removal of uterus.*—The cervix is next divided in a wedge-shaped manner, a little below the level of the internal os, and the uterus and attached tumour removed. A few small vessels on the surface of the stump may need ligature. This is best done by passing a buried suture beneath the bleeding spot, and tying it tightly. The pelvic cavity is cleared of all blood, and any further oozing arrested.

(*d*) *Closure of cervix.*—The margins of the cervical flaps are brought together and joined by a few points of suture, one or two buried sutures being inserted if necessary. The peritoneal flaps are now approximated over the cut surface of the stump, and the divided edges of the broad ligament closed. This is done by inserting a continuous suture of chromicised catgut.

In this way the whole of the operation field is enclosed and covered with peritoneum, and the pedicle is allowed to drop into the pelvis. The cavity of the pelvis and the field of operation are sponged clean, all protecting pads and sponges removed, and the omentum allowed to fall downwards towards the pelvis.

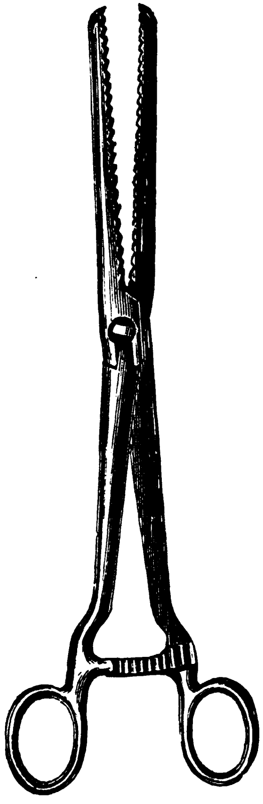

FIG. 239.—Hysterectomy. Large pressure forceps for applying to broad ligament close to the uterus, to control hæmorrhage.

(*e*) *Closure of external wound.*—The abdomen is closed in the usual way by three tiers of sutures.

Howard Kelly's Modification of Partial Hysterectomy.—In this method of removing a fibroid uterus, instead of tying and dividing the broad ligaments on either side *before* severing the pedicle, the operator works across the pelvis from one side to the other. After the broad ligament of one side has been ligatured and the uterine artery tied, the peritoneum in the region of the bladder is separated in the manner already described. Next, the cervix is cut across immediately above the vagina, the body of the uterus being drawn up and rolled towards the opposite side. As the last portion of the cervix is cut through, the other uterine artery becomes visible and is at once grasped with forceps, ligatured, and divided (Fig. 240). The body of the uterus is still farther drawn upwards and rolled towards the iliac fossa, and the broad ligament seized with pressure forceps and divided. By this

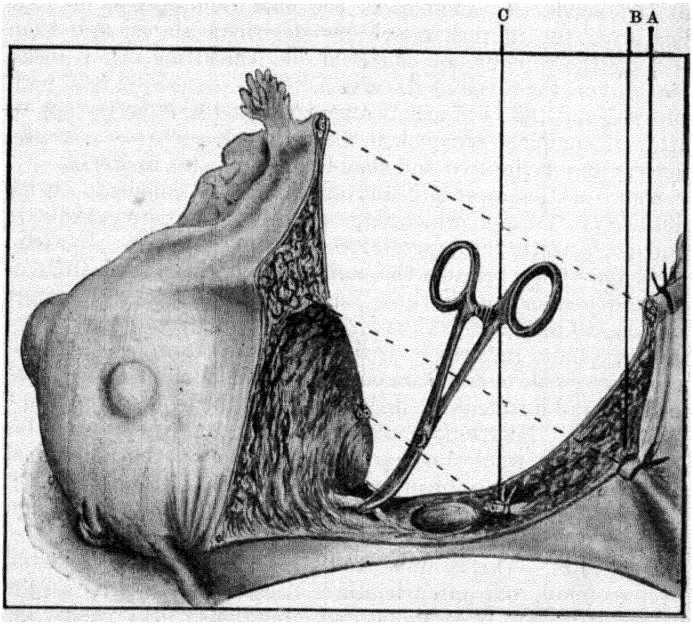

Fig. 240.—Method of division of broad ligament and removal of uterus in Kelly's *side-to-side* operation.—After Kelly.

A. Ovarian vessels. B. Round ligament. C. Uterine vessels.

The forceps is placed upon the right uterine artery.

proceeding the uterus and attached tumour, the ovaries and Fallopian tubes, are separated and removed. Peritoneal flaps are made as in the operation for partial hysterectomy. The wound area is covered with the peritoneal flaps, and the operation completed as described above.

Fibroids involving the cervix sometimes lead to difficulty in removal, as they expand the cervical portion and become jammed in the pelvis. In such cases the operation consists in first ligaturing the uterine vessels, as described above, and then shelling the tumour out of its capsule, consisting of the lower portion of the expanded cervix. This is now closed with sutures, and the peritoneum sewn over it. It is better not to attempt complete removal of the cervix in such cases, as the ureters may be injured and the bleeding difficult to arrest.

Some of the most difficult operations in connection with fibroids are those in which large cervical or subserous tumours burrow beneath the layers of the broad ligaments. In these cases they grow beneath the peritoneum, either in the front of the abdomen or posteriorly. They are very perplexing, as their anatomical relations to the uterus and other structures are very varied. Many have to be treated by enucleation, as described above for sessile ovarian tumours. Fibroids sometimes originate in the round ligament of the uterus, or in the ovary.

COMPLETE HYSTERECTOMY (PAN-HYSTERECTOMY).—In this operation the whole uterus is taken away by the abdominal route, and no stump of uterine tissue is left. It is undertaken when the position of a fibroid tumour does not permit of division through the cervix.

Operation.—This is similar to that for supravaginal or partial hysterectomy, but after ligature of the uterine arteries the vagina is opened from above. The relations of the vagina are carefully determined ; an assistant, if necessary, introducing his hand or a pair of long forceps into the vagina as the incision is being made.

It is preferable to open the vagina first posteriorly. Then the anterior fornix is also opened after determining the position of the bladder. The lateral attachments are now clamped and tied, and the remaining tissues cut through close to the cervix. The vagina is then closed with sutures, and the peritoneal flaps and cut edges of the broad ligaments approximated by a continuous suture.

Another method of performing pan-hysterectomy is to separate the cervix first through the vagina, at the same time ligaturing the lowest portions of the broad ligaments, and opening the anterior and posterior peritoneal pouches. The abdomen is then opened, and the operation completed from above.

Separating the cervix first in this way is said to facilitate the later stages of the abdominal part of the operation, as the vagina is already opened, and the bleeding, which is often very troublesome at this stage, has been controlled. It does not appear to me, however, that this combined operation presents any advantages over the abdominal one, and its adoption is not recommended.

Abdominal myomectomy. — In abdominal myomectomy the early stages of the operation are similar to those described in the operation of hysterectomy (hysteromyomectomy). After the peritoneal cavity has been opened through a median incision, and the field of operation isolated by careful packing with large flat gauze pads, the uterus with its attached fibroid tumour or tumours is lifted up into the wound. The exact character of the further procedures depends upon whether the fibroid tumour has a distinct pedicle attaching it to the wall of the uterus, or whether it is sessile, being partially or completely embedded in the thickness of the uterine wall, and of the so-called interstitial variety.

Pedunculated fibroid.—An oval incision is made around the base of the tumour, and the peritoneal and fibrous tissues peeled back for a short distance, and then, either the tissues forming the pedicle are cut through, or the tumour removed by enucleation. The margins of the wound are next brought into exact apposition, and fixed by the insertion of a number of sutures of chromicised catgut, a few deep sutures being inserted if necessary.

Interstitial or sessile fibroid. — When there are several tumours requiring removal, the incisions in the wall of the uterus should be so arranged that they are as few as possible, and are also parallel with one another. The circulation in the uterine arteries should

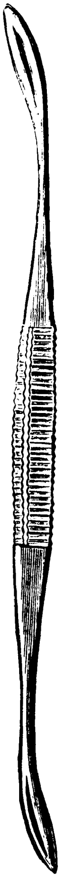

Fig. 241.—Enucleator for use in separating uterine fibromyomata.

be controlled by an assistant grasping the tissues around the supravaginal portion of the cervix between the index-finger and the thumb, and at the same time a rubber-covered clamp can be applied to the broad ligament on the uterine side of the ovary in order to control the circulation in the branches of the ovarian artery. An incision is next made through the peritoneum and portion of the uterine wall overlying the tumour, any bleeding points are picked up with pressure forceps and ligatured. The fibroid tumour is now grasped with a large volsellum, lifted up, and enucleated from its bed by using a blunt dissector ; in some cases it will be found convenient to divide the tumour vertically with the scalpel in the line of the original incision, and enucleate and remove each half separately. All further hæmorrhage is arrested, and the cavity from which the tumour has been removed obliterated by tiers of buried sutures. These sutures should be inserted with a round needle, in order to avoid laceration of the uterine tissue as much as possible. The most superficial tier of sutures includes the margins of the cut in the peritoneum. Other tumours requiring excision are treated in a similar manner.

The uterus and exposed portions of the pelvic viscera and peritoneum are sponged clean, the uterus returned into the abdomen, and the parietal wound closed as in abdominal hysterectomy.

The strictest aseptic precautions must be observed, and if during the operation it is found that there is evidence of septic infection, necrobiosis or degeneration of the tumour, or suppurative inflammation of one or other uterine (Fallopian) tube, the operation of myomectomy ought to be abandoned, and the uterus with the attached tumours excised by the method already described.

Abdominal operation for carcinoma of the uterus.—*Indications.*—During the last two decades a variety of operations have been performed by the abdominal route for the removal of a uterus, the seat of carcinoma. Until recently, however, the mortality which has resulted from these procedures has been so high that it has been questionable whether the operations were justifiable. However, the technique of the operation has been so much developed and improved that the results are beginning to approach those following the vaginal method. The most recent statistics show that in well-selected cases the mortality now is not more than 8 or 10 per cent. Moreover, the after-results are likely to be better, since the macroscopically diseased tissues can be more easily seen and removed, whereas in the vaginal operation portions of tissue infected with the disease may be invisible and are often left behind.

The cases which appear to be suitable for this form of operation are:

(*a*) Carcinoma of the cervix uteri, in which either the disease is limited to the cervix, or does not extend more than 1 inch

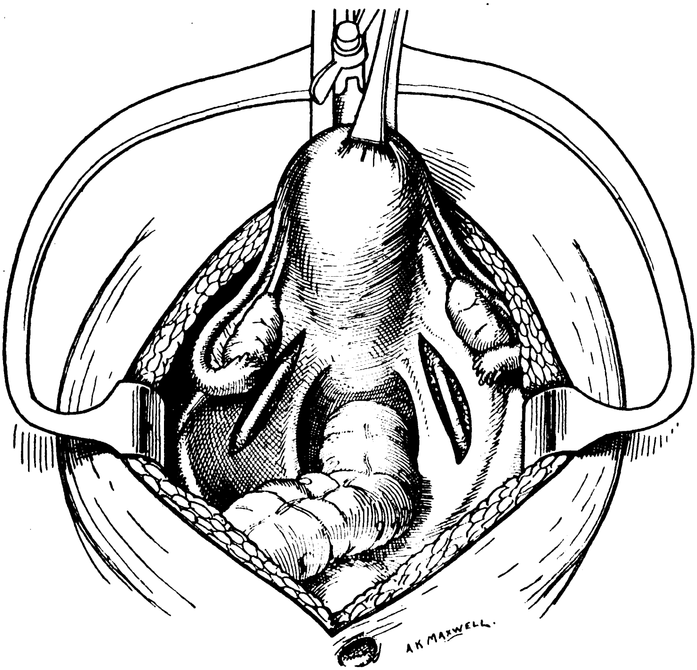

Fig. 242.—Abdominal hysterectomy for carcinoma. The uterus is lifted up and pulled forwards, and the peritoneum has been incised over the ureters.—After Kelly.

laterally into the tissues of the broad ligament, and is not associated with fixation of the broad ligaments, extension to the bladder in front, or the utero-sacral ligaments and sacrum behind.

(*b*) Carcinoma of the cervis uteri extending slightly to the posterior fornix of the vagina, and not extending elsewhere.

(*c*) Carcinoma of the body of the uterus, which is either limited to the uterus itself, or has only slightly extended into

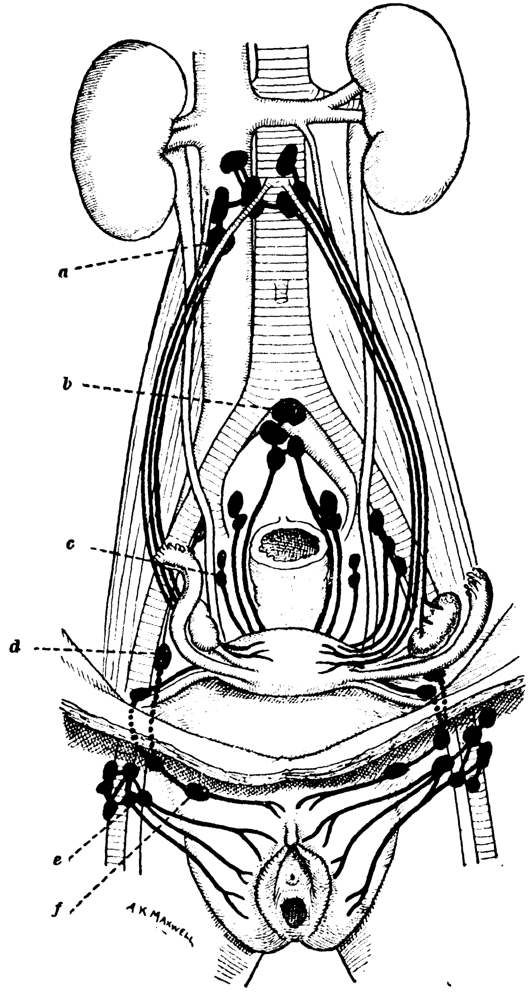

FIG. 243.—Arrangement of lymph vessels and lymph glands receiving lymph vessels from female genital organs.

a. Lateral aortic group of lymph glands.
b. Hypogastric ,, ,,
c. Internal iliac ,, ,,
d. External iliac ,, ,,
e. Deep inguinal ,, ,,
f. Superficial inguinal group of lymph glands.

the broad ligament, and is not associated with fixation of the uterus to adjacent viscera.

Involvement of the base of the bladder or the lateral portions of the vagina, or any considerable extension into the parametric tissues are, in my opinion, contra-indications to the performance of the radical abdominal operation for removal of a carcinomatous uterus.

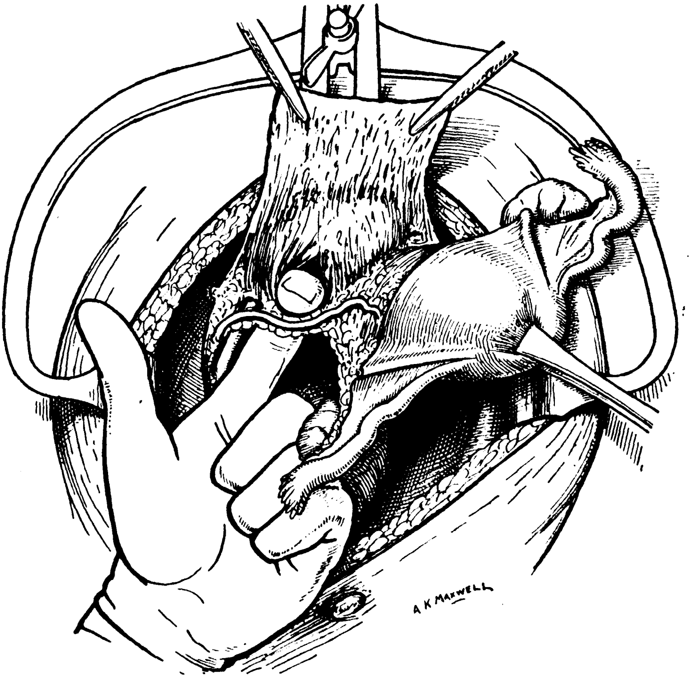

FIG. 244.—Abdominal hysterectomy for carcinoma. The uterus, Fallopian tubes, ovaries, and broad ligaments have been separated from their lateral pelvic attachments, and the index-finger passed underneath the left uterine artery along the course of the ureter.—After KELLY.

Preliminary preparations.—A few days before the date on which it is decided to perform the operation, the patient should be anæsthetised and, after washing out the vagina with an antiseptic solution, the entire cancerous area of the cervix uteri should be curetted, and cauterised with a Paquelin's cautery. From this date onwards until the operation, the vagina and the region of the cauterised cervix should be washed out daily with an antiseptic solution, and the upper portion of the vagina packed with a strip of gauze soaked in the same solution.

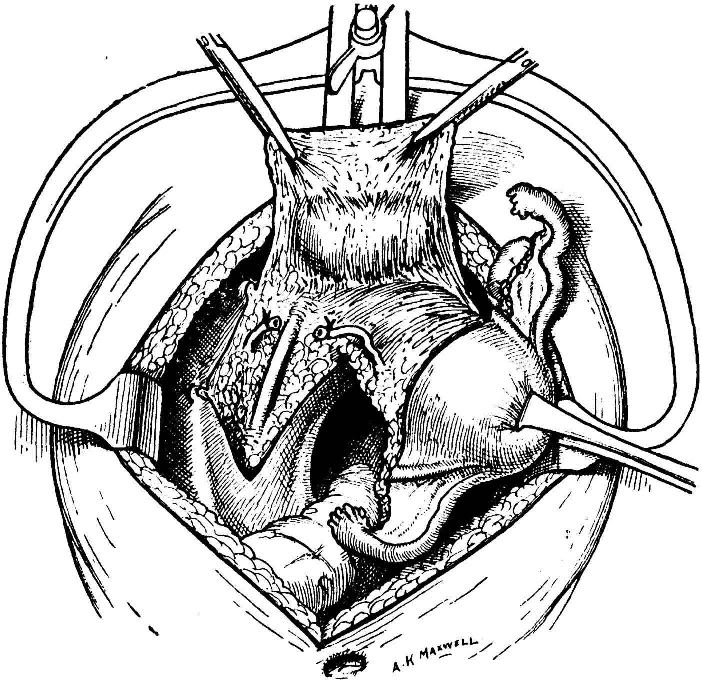

FIG. 245.—Abdominal hysterectomy for carcinoma. The left uterine artery has been ligatured and divided, the peritoneum and bladder dissected up, and the parametric tissues containing lymphatic vessels and glands exposed.—After KELLY.

Special instruments.—Large clamp forceps, right-angled forceps, long-toothed dissecting forceps, blunt dissector, aneurysm needle, Paquelin's cautery, thin red-rubber sheeting.

Position.—The patient is placed in the dorsal position with the pelvis raised (Trendelenburg); the surgeon stands on the left side of the patient and the assistant on the right.

Operation.—Abdominal hysterectomy for carcinoma of the uterus may be described in the following stages :—

(*a*) *Parietal incision, exposure, and investigation of the diseased structures.*—An incision is made through the abdominal wall in the middle line from a point a little below the umbilicus (or above in stout patients) to immediately above the symphysis pubis, and the peritoneal cavity opened.

The abdomen having been opened, the dependent portion of the great omentum and the lower coils of small intestine are drawn out of the pelvis and pushed upwards, kept in this position by packing with large flat gauze pads, and the pelvic viscera thus exposed to view. A careful examination of the uterus, broad ligaments, and adjacent abdominal viscera is now made in order to ascertain the extent of the disease, the mobility of the uterus, the nature and extent of its attachments to surrounding viscera, and the condition of the pelvic lymphatic glands. It is very important to determine the degree of fixation or mobility of the broad ligaments and parametric tissues at the sides and back of the cervix uteri, since if the movements are very limited it is probable that carcinomatous infiltration of the connective tissues has extended widely, and the operation should not be proceeded with. If the lymph glands, which lie laterally and along the course of the hypogastric (internal iliac) veins, are the seat of extensive secondary growths, or if they are adherent to the tissues on the sides of the pelvis, it is usually unwise to make an attempt to remove the entire diseased structures.

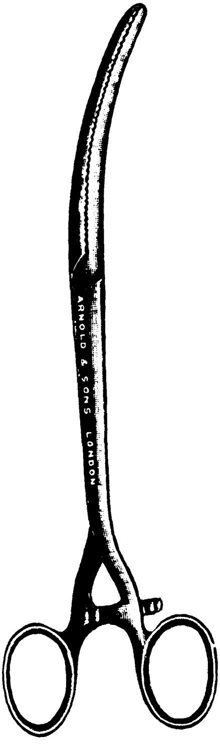

FIG. 246.—Forceps for grasping portions of broad ligament.

(*b*) *Ligation and division of ovarian vessels, round ligament of uterus, infundibulo-pelvic ligament, and exposure of ureters.*—The surgeon, having decided to proceed with the operation, first protects the margins of the parietal wound with thin red-rubber sheeting in order to prevent possible contamination from the cancerous uterus, and then grasps the uterus with a large, blunt volsellum and draws it forcibly upwards and towards one side, and applies, after transfixion, a ligature to the opposite infundibulo-pelvic (ovario-pelvic) ligament on the outer side of the ovary, so as to include the ovarian vessels, and another in a similar manner to the round ligament 1½ inch from its attachment to the uterus. A large curved clamp (Fig. 246) is next applied to the broad ligament on the uterine side of the ligatures, and the ligament divided between the ligatures and the clamp, the ovaries and uterine (Fallopian) tubes being removed along with the uterus and broad ligaments.

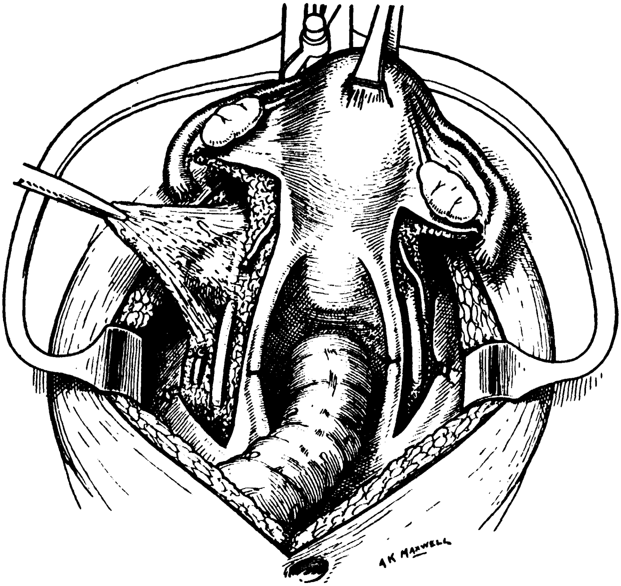

FIG. 247.—Abdominal hysterectomy for carcinoma. The uterus has been drawn forwards, both uterine arteries ligatured and divided, and ligatures applied to the utero-sacral ligament on each side.—After KELLY.

After dividing the peritoneum of the broad ligament by an incision commencing over the bifurcation of the common iliac artery, and continued forwards and inwards, the ureters are sought for. A cellular or fascial space is thus opened up, in which the ureter is identified after careful dissection with a blunt dissector or the finger. The ureter is practically always found to be adherent to the posterior layer of the two separated folds of the broad ligament, and, usually, can be readily seen, or if not seen, it can be felt as a rounded cord with a firm wall. In dissecting down upon the ureter, care must be taken not to separate it from its fascial sheath, or to injure the blood vessels which supply it and are in close approximation to its outer aspect. Injury of these may cause sloughing of the ureter.

(*c*) *Division of peritoneum an anterior aspect of uterus, separation of bladder, and exposure and ligature of uterine arteries.*—The incisions in the peritoneum of the broad ligaments are now continued round in front of the uterus at the utero-vesical reflection, the uterus is drawn upwards, and the bladder separated downwards as far as possible from the cervix and the anterior wall of the vagina by sponge pressure. The lateral attachments of the uterus are next divided as far down as the uterine artery. This vessel can be felt and lifted up by the index-finger hooked underneath it. The artery is ligatured at the lateral pelvic wall, but not before the exact position and course of the ureter as it lies in the fibrous or fascial canal close to the cervix has been defined. After dividing the uterine vessels as near the lateral pelvic wall as possible, the course of the ureter to the point where it enters the bladder is exposed to view. A similar procedure is carried out on the opposite side. The uterus is now almost separated from its connections, and only remains held by the deep parametric attachments, the utero-sacral folds of peritoneum, and the vagina.

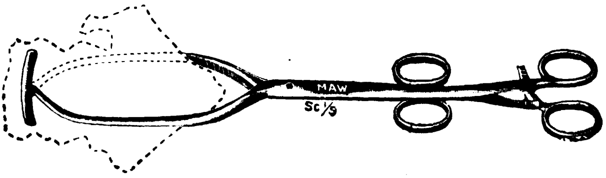

FIG. 248.—Tractor forceps for seizing vagina below cervix of uterus. —BERKELEY-BONNEY.

(*d*) *Division of peritoneum of broad ligaments posteriorly, application of clamps to and division of vagina, and removal of uterus and attached tissues.*—The uterus is next pulled forwards, and the utero-sacral reflection of peritoneum divided, the rectum being pushed downwards towards the bottom of the pelvis. The parametric tissues laterally and posteriorly are seized with forceps and cut through. The uterus is now entirely free except for its vaginal attachments. The vagina is then grasped with two pairs of rectangular forceps and divided between, as shown in Fig. 250; or in difficult cases a large tractor forceps (Berkeley-Bonney) of the shape shown in Fig. 248 is applied to the vagina, a short distance below the cervix. It is important that the blades of the forceps applied to the vagina should overlap a little, so that the vaginal lumen is completely closed, and hence escape of cancerous secretions or material prevented, after division. The vagina is cut through transversely between the two pairs of forceps, either with strong scissors or a cautery. Better results appear to have followed the use of the cautery in this stage, and therefore its use is recommended. The uterus and attached structures are now free, and can be removed. The margins of the divided vagina are examined for bleeding points, and if any are found they are seized with pressure forceps and ligatured. All further bleeding points are also ligatured, and the lateral portions of the stump of the vagina sewn up, and it is then allowed to drop back into the pelvis, the open portion serving for free drainage.

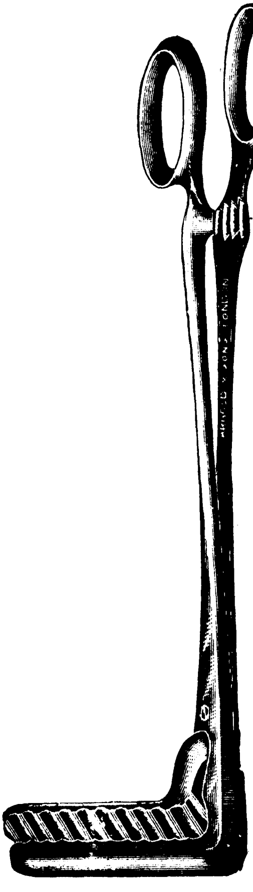

FIG. 249.—Rectangular forceps for vagina.

(*e*) *Removal of enlarged pelvic lymph glands, and ligature of parametric tissues on floor and lateral aspects of pelvis.*—The lateral aspects of the pelvis along the course of the iliac vessels, particularly in the angle between the external iliac and hypogastric (internal ilia) arteries, should be investigated for enlarged lymph glands, and if any are found they are dissected from their surroundings and removed. An infected lymph gland is sometimes found on the pelvic side of the obturator membrane.

The parametric tissues held by the clamps are now transfixed and ligatured with medium chromicised catgut, great care being taken in this proceeding to arrest completely all hæmorrhage from the veins on the lateral aspect and the floor of the pelvis. The tissues in the neighbourhood of the vaginal stump require particular attention, since in this region troublesome bleeding may occur.

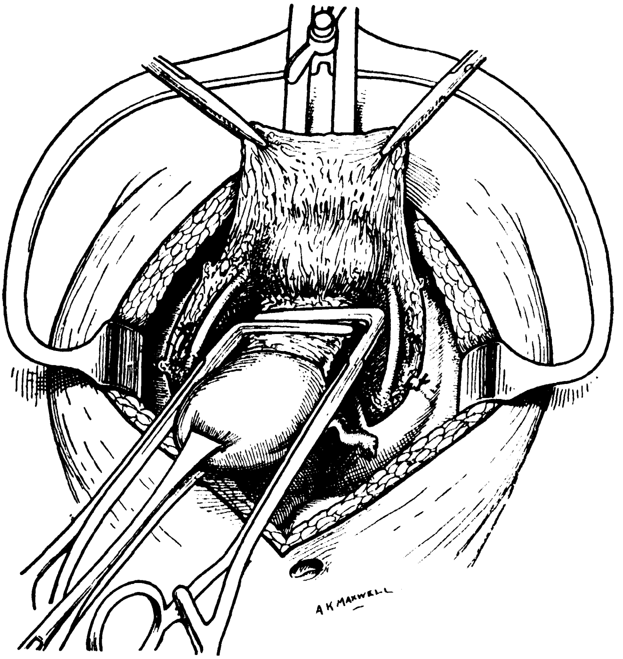

FIG. 250.—Abdominal hysterectomy for carcinoma. The uterus has been separated from the bladder in front and the rectum behind, and two pairs of rectangular clamps applied to the vagina so as to occlude the lumen.—After KELLY.

(*f*) *Approximation and suture of cut margins of peritoneum anteriorly and posteriorly, and treatment of stump of vagina.*—The margins of the divided vesical and rectal reflections of peritoneum are approximated and fixed in apposition by the insertion of a continuous suture of chromicised catgut, several knots or interruptions being placed along the line of the suture. Often it is necessary to join together the walls of any interfascial space which may be apparent by buried sutures of fine chromicised catgut. This will help to avoid the formation of collections of fluid secretions, in which septic processes readily occur.

As regards the stump of the divided vagina, the lateral portions should be joined together by sutures (if this has not been done already), and the central part left open, and in it placed a strip of gauze, the lower portion of which is placed in the vagina. This will allow of free drainage and tend to avoid the occurrence of collections of blood and serum, or localised suppuration.

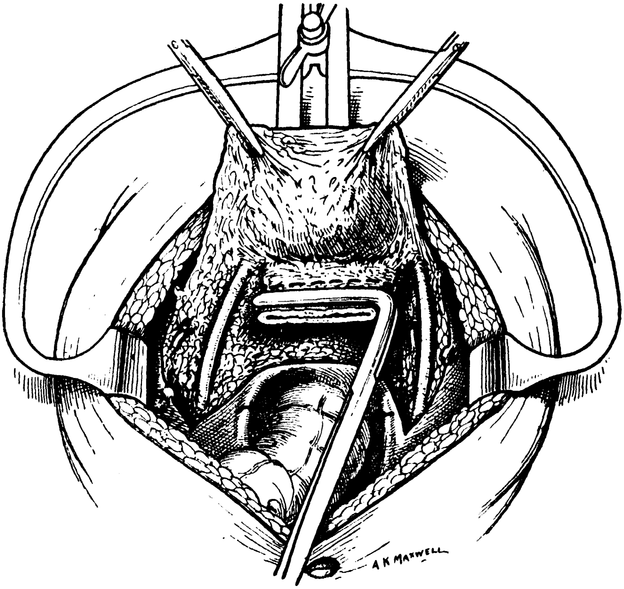

FIG. 251.—Abdominal hysterectomy for carcinoma. The uterus has been removed after dividing the vagina between the two clamps. —After KELLY.

(*g*) *Closure of external wound.*—The external wound is closed by the insertion of three tiers of sutures in the usual manner, particular attention being given to the fixation of the vesical peritoneum to the deep aspect of the lower part of the wound, otherwise an interfascial space may be left in which collections of blood, serum, or pus may readily form.

After-treatment.—The after-treatment is the same as that after any severe abdominal or pelvic operation. If the patient suffers much from shock at the termination of the operation, injections of hot saline solution into the rectum and pelvic colon should be at once resorted to. In practice this will generally be found advisable at the end of an abdominal hysterectomy for carcinoma of the uterus. Particular attention should be paid to the evacuation of the urine and prevention of cystitis, a complication which is very liable to happen on account of the interference with and injuries to the urinary bladder during the performance of the operation.

Ventral fixation of the uterus—hysteropexy.—By ventral fixation of the uterus is understood apposition and suture of the fundus of the uterus to the deep aspect of that portion of the anterior abdominal wall immediately above the symphysis pubis.

Special instruments.—Blunt volsellum forceps, and large curved needles.

Position.—The patient is placed in the Trendelenburg position. The surgeon stands on the right side, and the assistant opposite to him.

Operation.—The abdomen is opened in the hypogastric region by a short median incision 2 inches in length. The recti muscles are separated, and the peritoneum stripped off from their under surface for about an inch on either side and then incised. The uterus is now felt for by the fingers, and raised up into the abdominal incision. A large curved needle, threaded with silk, is passed from side to side through the tissues of the posterior surface of the uterus at the junction of the fundus and body—the suture entering near one uterine (Fallopian) tube and emerging near the opposite one. Each end of the suture is now passed through the recti muscles on either side from their deep aspect. Two similar stitches, one above and the other below the first, are also inserted. The peritoneum above and below these stitches is closed with fine catgut.

The fundus is thus held in apposition with the muscles of the abdominal wall (not with the peritoneum). The three uterine stitches are now tied, and the ends cut short, the knots lying upon the upper surface of the rectus sheath. The rest of the incision is closed by sutures in the usual way.

Ventral suspension of the uterus.—In this operation the abdomen is opened as above, the uterus brought into the wound, and the round ligaments of the uterus fixed by sutures to the margin of the sheath of the rectus. This method allows a certain amount of mobility to the uterus, and is thought to be a better operation than the one above described when the patient has not passed the menopause. The results obtained, however, do not appear to be such that the operation can be recommended.

Cæsarean section.—In this operation the fœtus and placenta are removed from the uterus by abdominal section.

Indications.—Cæsarean section is performed for extreme degrees of pelvic contraction and for tumours of the pelvis or uterus, which obstruct labour. Cancer of the cervix, certain cicatricial conditions of the passages, and osteo-malacia may also necessitate the operation. The indications for Cæsarean section are of two kinds, absolute and relative. Absolute indications are conditions which make delivery in any other way impossible. The relative indications are conditions in which it is possible to deliver in other ways, but it is judged that Cæsarean section is the best, though not the only way.

Special instruments.—As for ovariotomy.

Position.—As for ovariotomy. A special assistant is directed to look after the child.

Operation.—(*a*) *Parietal incision and exposure of uterus.*—An incision 5 or 6 inches in length is made through the abdominal wall, beginning in the middle line near the umbilicus, but not extending too far down into the pubic region. The limits of the bladder should be carefully defined. It is well not to cut too deeply at first, as the abdominal walls are often very thin, and the uterus may be wounded at this stage.

(*b*) *Incision through wall of uterus, removal of fœtus, placenta, and membranes, and arrest of hæmorrhage.*—The central portion of the anterior aspect of the uterus is made to protrude, the abdominal wound is hooked upwards by the finger, and a vertical incision is made through the uterine wall at its upper portion, *i.e.* in the *upper* uterine segment. When the fœtal membranes are reached, the wound is rapidly enlarged upwards and downwards. It is best not to cut into the lower uterine segment. This can be determined by the loose attachment of the peritoneum to the lower portion of the uterus. The uterine incision should be at least 6 inches in length ; if the placenta lies beneath the incision, it may be cut through. Bleeding at this period of the operation is generally free. The membranes being ruptured, the child is extracted as rapidly as possible by grasping a knee. The umbilical cord is clamped or tied, and the child handed to the care of the special assistant. The uterus should now contract, and is brought out of the wound and held by the other assistant, while the placenta and membranes are removed. The uterus now contracts farther, and much of the bleeding will stop, though it will not finally cease till the wound is sutured. Kneading the uterus, or surrounding it with hot gauze sponges, will aid its contraction.

(*c*) *Suture of uterine wound.*—The wound in the uterus is closed by means of deep and superficial sutures. Chromicised catgut should be used. The deep sutures include the muscular layers, but *not* the mucosa; as a rule, six or eight deep stitches are sufficient. The superficial sutures are passed on each side, through the peritoneum only, by Lembert's method, and care taken that good peritoneal apposition is obtained.

Very little difficulty is met with in closing the uterine incision, as long as this only occupies the contractile upper uterine segment. If the lower segment is cut into, great care should be taken to close the incision in this region very accurately, as leaking of blood beneath the loose peritoneum may give rise to a considerable hæmatoma.

(*d*) *Removal of uterine* (*Fallopian tubes*) (*if requisite*) *and closure of parietal wound.*—If the condition requiring Cæsarean section is one that is permanent, the patient should be sterilised, in order that she should not run the risk of a subsequent pregnancy. Sterilisation is generally performed by ligature and resection of a portion of each of the tubes, though even this has failed in preventing subsequent conception. The ovaries should not be removed unless for the cure of osteo-malacia. Probably the best method of sterilisation is to perform *salpingectomy.* The tube is drawn out of the abdominal wound and its mesosalpinx clamped and ligatured much as in removing the vermiform appendix. The ovary is left *in situ.* The tube is finally cut across close to the uterine end, and its mucous membrane cauterised with liquefied carbolic acid. The stump is now pushed inwards towards the uterine cavity, and the serous and muscular tissues sewn over it by the insertion either of a purse-string suture or two Lembert's sutures, whichever is the more convenient. The abdominal wound is closed in the usual way.

OPERATIONS FOR EXTRA-UTERINE GESTATION

The operative treatment of cases of extra-uterine gestation may be discussed under the following headings, namely:—

I. Cases coming under observation in the early months of pregnancy (before the fifth month).—(*a*) Before rupture has taken place; (*b*) at the time of rupture; (*c*) after rupture has occurred.

II. Cases coming under observation in the late months of pregnancy.—(*a*) When the fœtus survives; (*b*) when the fœtus is dead.

I. Cases coming under observation in the early months of pregnancy.

(*a*) *Before rupture of tube or sac.—Indications.*—When an extra-uterine gestation has been diagnosed, or it is suspected that such a condition exists, an operation should be undertaken at once. No good usually comes of delay, since the patient runs the risk of rupture of the dilated uterine (Fallopian) tube, and consequent severe hæmorrhage and its complications. Moreover, an operation for removal of an unruptured extra-uterine pregnancy is accompanied by less risks than when rupture has taken place.

Operation.—The operation is similar to that for removal of the uterine appendages. The abdomen is opened by a vertical incision in the hypogastric region, the great omentum and coils of intestine pushed upwards, packed away with gauze pads, and the pelvis examined. The uterine (Fallopian) tubes and broad ligaments should be carefully palpated, and the position, size, and relations of the sac determined. The tubal sac is next drawn upwards into the parietal wound, care being taken to avoid rupturing it, and any adhesions which may be present separated by sponge pressure, or by ligature and division. Clamp forceps are next applied to the broad ligament on the uterine side, and to the infundibulo-pelvic (ovario-pelvic) ligament—in order to control the circulation in the blood vessels and hence avoid the occurrence of hæmorrhage. A pedicle usually with a broad base is now defined, transfixed with a pedicle needle, and ligatured with medium silk or chromicised catgut, the clamps on the broad ligament and the infundibulo-pelvic ligament being taken off as the ligatures are tied. The ligatures should not be tied too tightly, otherwise the soft tissues may be cut through, and troublesome oozing be set up. The dilated uterine (Fallopian) tube with its contents is now cut away and removed, the cut surface of the pedicle being sponged in order to determine if the blood vessels have been occluded. If possible the ovary is left behind, but very commonly it has to be removed along with the distended tube or sac. Next, the pelvic cavity is sponged dry, the protecting gauze pads taken out, and the parietal wound closed by the insertion of tiers of sutures in the usual manner.

(*b*) *At the time of rupture of tube or sac.—Indications.*—(*a*) Rupture of uterine (Fallopian) tube or extra-uterine sac; (*b*) tubal abortion into peritoneal cavity. Both rupture of the Fallopian tube and tubal abortion into the peritoneal cavity are usually associated with the occurrence of severe hæmorrhage, and immediate operation is necessary. Often a diagnosis between these two conditions cannot be made until the abdomen has been opened and the source of bleeding exposed. Rupture may also take place into the tissues of the broad ligament, in which case the hæmorrhage is not so severe.

Operation.—The abdomen is opened as in the previous operation. When the peritoneum has been divided, blood will usually exude, or if there has been much hæmorrhage it may gush out in considerable force. If the rupture is very recent, or hæmorrhage is not very extensive, it is necessary to draw upwards the great omentum and any coils of intestine which hang down into the pelvis before the ruptured tube is exposed to view. In those cases in which there is much blood-clot this is rapidly scooped out of the peritoneal cavity with the hand, and if bleeding appears to be still going on, the intestines and omentum are quickly held aside, and the hand passed down into the pelvis, where the uterus and broad ligaments are palpated in order to locate the position of the ruptured tube. When this is found, it is drawn upwards into the parietal wound and a long clamp placed on the broad ligament on the uterine side of the sac, and a second one upon the infundibulo-pelvic ligament on the lateral wall of the pelvis. This proceed-

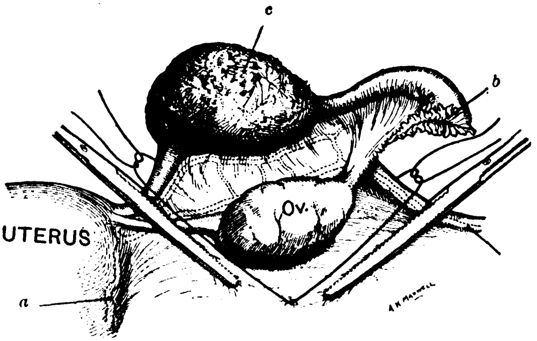

FIG. 252.—Uterus and uterine (Fallopian) tube. The latter is dilated by a tubal pregnancy.

a. Uterine artery. *b.* Abdominal ostium of uterine (Fallopian) tube. *c.* Tubal pregnancy.

ing will control any hæmorrhage which may be going on. The peritoneum and the pelvic cavity are next completely freed from clots and blood, and the bottom of the pelvis sponged dry. The intestines and omentum being packed out of the way with large gauze pads, ligatures are applied to the ligaments on each side of the sac or ruptured tube, as in the previous operation, and the ruptured portion removed. The gauze pads are now removed, the intestines and omentum replaced, and the parietal wound closed. No drainage is requisite, unless a septic condition is met with in the pelvis.

(*c*) *After rupture of the tube or sac.*—*Indications.*—This group comprises those cases which are first seen some time after rupture of the tube or sac, or when tubal abortion has occurred. In most cases of this kind the fœtus dies immediately after rupture, whether this takes place into the peritoneal cavity or between the layers of the broad ligament. The object of treatment then is the removal of the collection of blood, fœtus, placenta, and membranes from wherever it is located, either in the pelvis surrounded by adherent omentum and matted intestines, or between the layers of the broad ligament. Often effusions of blood into the pelvic cavity (pelvic hæmatocele) remain quiescent for a time or become absorbed, and hence no operation is necessary. Should, however, signs of repeated bleeding become manifest, accompanied by attacks of pain and anæmia, the abdomen should be opened without delay.

Operation.—The operative procedures are similar to those already described, with the exception that more extensive and firm adhesions of the sac to the adjacent omentum, coils of intestine, or parietal peritoneum, will be met with, and will require careful separation, or ligature and division. Usually these can be satisfactorily dealt with, and the sac and blood-clot removed. After this has been done, the pelvic cavity, and wherever there have been adhesions, are carefully sponged in order to ensure that all hæmorrhage has been arrested. The abdomen is then closed in the usual manner. It is not generally necessary to drain the sac, although, where venous oozing is considerable, it will be convenient to pack the cavity with long strips of gauze, which can be removed at the expiration of about thirty-six hours. Should suppuration be found, the cavity must be evacuated and satisfactory drainage established either through a portion of the parietal wound or through the vagina.

When an extra-uterine gestation which has ruptured some time previously is under consideration, and when there is no evidence of further hæmorrhage, and the swelling can be readily felt through the vagina, the best plan to pursue is to incise and drain it through the posterior vaginal fornix. The operator, however, in cases of this kind must be prepared occasionally to meet with severe hæmorrhage after the sac has been opened, and if it cannot be immediately arrested he must at once open the abdomen, after the manner already described, and deal with it from above.

When rupture has taken place into the broad ligament the usual method of treatment is to incise the sac per vaginam, evacuate the contents, and establish drainage. It is safer not to perform this operation less than a fortnight after the occurrence of rupture, unless hæmorrhage is still going on, in which case the abdomen should be opened, and the condition treated from above. After a rupture has taken place into the blood ligament, it occasionally happens that the collection of blood, etc., extends along the broad ligament between its layers, and ultimately forms a fluid swelling, which forms a prominence of the anterior abdominal wall a little above the central portion of Poupart's ligament. In these cases, incision and drainage should be carried out through the prominent portion of the abdominal wall.

The quantity of blood poured out in many of these cases, however, is not great, and if left alone becomes absorbed. On this account, unless the pelvic swelling is large, or increasing in size, or shows evidence of the occurrence of suppuration, it is better to adopt expectant treatment.

II. Cases coming under observation in the late months of pregnancy.

(*a*) *When the fœtus survives.*—In these cases the dangers of operation increase as pregnancy advances. No good seems to come of expectant treatment, and it is the wisest plan to operate as soon as convenient after the diagnosis has been made, in order to avoid the occurrence of secondary rupture. During such operations great difficulty is often experienced in dealing with the placenta. Since, so long as the circulation in it continues, severe hæmorrhage almost invariably results when it is detached from its connections, an attempt should be made to ligature the large blood vessels going to the sac, or to pass ligatures into the tissues all the way round the placental attachment. If the hæmorrhage can be controlled by these measures, the placenta and sac are removed, the fœtus being first extracted from the sac.

When the risk of removal is very great on account of hæmorrhage, the sac should be opened, the umbilical cord tied, and the fœtus removed. The space is packed with gauze, and the margins of the opening in the sac sutured to those of the lower part of the parietal wound. The placenta separates and is discharged later.

(*b*) *When the fœtus is dead.*—When the fœtus has been dead for several weeks the operative risks are very much less, as the placental circulation has ceased. If, however, the fœtus has recently died and a placental bruit can still be heard, the surgeon should wait for two or three weeks, by which time the placental vessels will have become occluded.

Operation.—The abdomen is opened as in the previous operation, and the position of the sac and placenta defined. The adjacent portions of the peritoneal cavity are shut off by protecting pads, and the sac and placenta separated from their attachments, fibrous adhesions being ligatured and divided wherever necessary. The sac and contents are then removed. All hæmorrhage having been arrested, the cavity is sponged dry and the parietal wound closed in the usual manner. When there is much oozing or a septic condition is met with, drainage must be established.

CHAPTER XII

OPERATIONS UPON THE NOSE AND ITS ACCESSORY CAVITIES

BY

W. DOUGLAS HARMER, *Surgeon to the Department for Diseases of the Throat and Nose, St. Bartholomew's Hospital*

SUBMUCOUS RESECTION OF DEVIATED NASAL SEPTUM.

REMOVAL OF NASAL POLYPI—
  With a snare.
  With forceps.
  With curette.

REMOVAL OF NASO-PHARYNGEAL POLYPUS—
  (*a*) Through the nose.
  (*b*) Through the mouth.
  (*c*) After resection of the upper jaw.

DRAINAGE OF MAXILLARY SINUS (MAXILLARY ANTRUM) (ANTRUM OF HIGHMORE).

DRAINAGE OF FRONTAL SINUS.

REMOVAL OF ADENOIDS.

Submucous resection of deviated nasal septum.—A small amount of deviation of the nasal septum to one or other side is commonly met with, but unless it is considerable, no inconvenience is caused by it. The operation may be performed for the relief of—(1) Nasal obstruction ; (2) catarrh of the nasal fossæ or sinuses, naso-pharynx, Eustachian tubes, larynx, or lungs ; (3) asthma ; (4) reflex nasal headaches, and to facilitate the treatment of polypi and sinusitis.

Special instruments.—Long nasal speculum, head mirror, small scalpel, periosteal elevator, knife for cartilage, bone forceps, gouge and mallet, needle.

In order to constrict the vessels and prevent troublesome bleeding, the nasal cavities should be plugged with wool soaked in a solution of cocaine (10 per cent.) and one-tenth part of adrenalin (1–1000), a quarter of an hour before the operation commences. Care should be observed that the cocaine is not swallowed. Though it is possible to perform the operation with local anæsthesia alone, a general anæsthetic may be preferred. The operation should be performed in a darkened room, the light from a strong lamp being reflected by the head mirror into the nose.

Operation.—The patient having been anæsthetised, and the plugs removed from the nose, an examination of the nasal septum is made through the speculum (Fig. 253) in order to locate the position of the deviation, and any spur that may be present. With the scalpel a vertical incision is made through the mucous membrane immediately in front of the prominent part of the deflection, on the convex side of the septum when this is possible. The incision commences at the roof, and passes down to the floor of the nose. The muco-periosteum is separated with a small elevator (Fig. 254, *a*) from the convexity of the septum, taking care not to buttonhole the flap. The deflection usually extends a considerable distance towards the posterior nares, and it may be impossible to separate all the soft tissues from the convexity at this stage, especially if the spur or crest is very sharp. A vertical cut is then made through the cartilage in the same position as the original incision, and the elevator is introduced through this opening to separate a flap of muco-periosteum from the concavity of the septum. The speculum

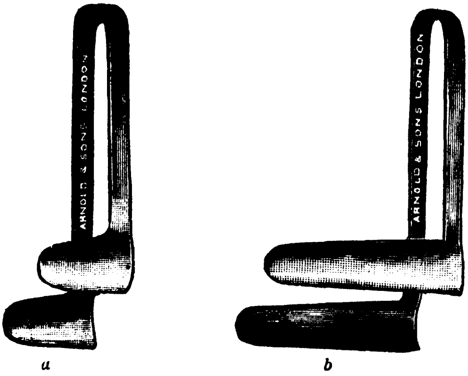

FIG. 253.—Nasal specula.

a. Short form. *b.* Long form.

is reintroduced in such a manner that the two flaps lie to the outer side of the blades where they are protected, and the bared cartilage and bone between the blades. The cartilage is then removed with the knife (Fig. 254, *c*), and the bone with cutting forceps or chisel and mallet. The process of baring the bone and removing it is then repeated, and when the whole deformity has been taken away the two flaps are allowed to fall together with their raw surfaces in apposition, and the original incision is united with one or two horsehair sutures. In order to keep the flaps in apposition, gauze is packed into both nostrils.

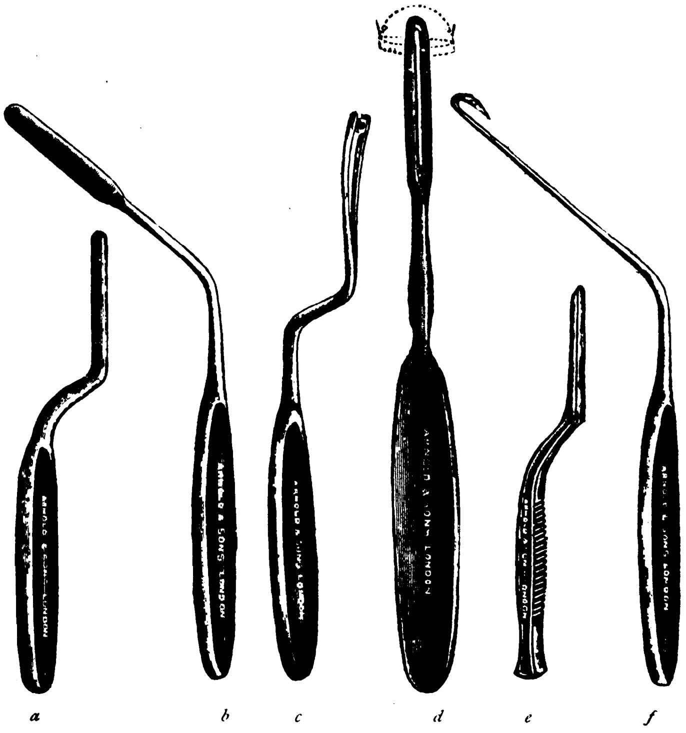

FIG. 254—Instruments for submucous septum operation.

a. Periosteal elevator.
b. Periosteal elevator.
c. Knife for cartilage (Killian).
d. Knife for cartilage (Ballenger).
e. Chisel (Killian).
f. Hook needle.

With the employment of cocaine and adrenalin there is practically no hæmorrhage, and the operation, if well carried out, gives better results than other methods. No perforation should be made, and the septum should be perfectly straight, thus allowing free breathing through both nostrils. In some instances it may be necessary to remove a portion of the inferior turbinate or middle turbinate bones, especially the anterior ends in the concave side.

After-treatment.—The gauze is removed twenty-four or forty-eight hours after the operation, and further plugging is unnecessary unless there is serious hæmorrhage. Healing should be rapid, and mucus and clots should quickly disappear. In some instances it is advisable to irrigate the nose twice daily with an alkaline lotion.

Removal of nasal polypi.—Mucous polypi of the nose usually grow from the muco-periosteum covering the ethmoid, and are most commonly attached to the middle turbinate bone, a fact which must be remembered when an attempt is being made to detach them.

Occasionally a nasal polypus may be fibrous in character, in which case it will be found to take its origin either from the roof of the nose, or from the periosteum covering one of the bones which enter into the formation of the nasal cavity. In still rarer instances the polypi may be malignant (carcinomata or sarcomata).

Nasal polypi may be removed either with some form of snare, with forceps, or with curette. When malignant polypi have to be removed it is necessary to perform a more radical operation, and the nasal cavity must be opened up, as in Rouge's operation.

(a) Removal by snare.—The interior of the nose should be plugged with wool containing a 10 per cent. solution of hydrochloride of cocaine before the operation is commenced.

Special instruments.—Lamp, forehead mirror, nasal speculum, nasal forceps, probe, and wire snare.

Position.—The patient is seated in a chair of suitable height, with his back towards the source of light, whilst the surgeon sits opposite the patient, and facing the source of light.

Operation.—The nasal speculum (Fig. 253) is introduced into the anterior nasal aperture of the affected side, and the blades separated. The position of the polypus is made out, a probe being used, if requisite, to define its attachment, and then the wire loop of the snare is passed around it (Fig. 255), and directed upwards and outwards so as to grasp the pedicle close to its attachment. The loop being tightened, the polypus with its base of attachment is removed through the speculum by strong pulling. Other polypi are sought for and dealt with in a similar manner. The nostril of the other side is next examined, and treated. If there is extensive bone disease or sinus suppuration a more radical operation is necessary, under general anæsthesia, in order to take away the whole of the disease.

Sometimes it is necessary to excise projections or spurs to obtain a good view of the upper part of the nose.

The nose must be kept as free from blood and mucus as possible during the operation, otherwise small polypi will escape notice. These will afterwards increase in size, and necessitate a further operation.

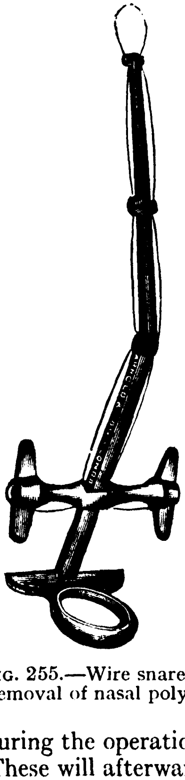

FIG. 255.—Wire snare for removal of nasal polypi.

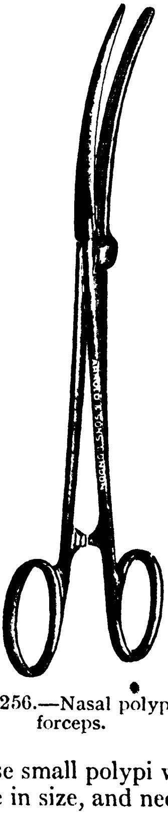

FIG. 256.—Nasal polypus forceps.

The galvanic wire loop, though convenient for the removal of nasal polypi, is liable to set up inflammation of the bone, and is not recommended.

(b) Removal with forceps.—The preparation of the patient, the instruments, with the exception that the wire snare or loop is replaced by nasal forceps (Fig. 256), and the positions of the patient and operator, are the same as in the preceding operation.

Operation.—The nasal speculum having been introduced, the position of the polypi is made out. Next, the blades of the nasal forceps are introduced through the aperture in the speculum, the polypi are seized near their bases and forcibly avulsed. Usually small portions of the turbinated bones, together with the mucous membrane covering them, are pulled away when the forceps are used. When the polypi are located far back in the region of the naso-pharynx, their removal can be facilitated by passing the forefinger of the left hand behind the soft palate (from the mouth), and pushing the growths between the blades of the forceps, which have been passed backwards along the middle meatus of the nose.

(c) **Removal with curette.**—This method is employed where the polypi are very numerous and the ethmoidal cells are blocked with swollen mucosa and discharge. The curette or sharp spoon must be kept against the outer wall of the nasal fossa and used to break down the partitions between the different cells so that the pockets are thoroughly cleared out. Care must be taken not to injure the cribriform plate for fear of meningitis, nor to fracture the wall of the orbit, an accident which causes emphysema and hæmorrhage into the eyelids.

After-treatment.—Hæmorrhage caused by the removal of non-malignant nasal polypi usually stops spontaneously, shortly after the operation. If it continues it may be necessary to pack the nostril with strips of aseptic gauze, which should not be retained for more than forty-eight hours. Before this is done, injection of liquid paraffin or gauze moistened with peroxide of hydrogen (10 vols.) should be tried.

Afterwards, the nose is irrigated twice daily with a dilute antiseptic solution or a weak alkaline lotion. This treatment is continued for a few days, until all discharge from the nose has ceased. It may be necessary to repeat the operation if the polypi are numerous.

Removal of naso-pharyngeal polypus.—Naso-pharyngeal polypi grow (1) from the periosteum of that portion of the base of the skull which forms the roof of the naso-pharynx—that is to say, the basilar portion of the occipital bone and the base of the sphenoid; (2) from the roof or outer wall of the nasal cavity, in which case they may invade the maxillary sinus.

These polypi may be either simple or malignant in character: when simple, they may be fibro-myxomatous tumours possessing definite pedicles, or fibro-angeiomatous with a broad base of attachment. When malignant, they are generally sarcomata, or more rarely endotheliomata.

Care must be taken, before commencing an operation on a naso-pharyngeal tumour, to ascertain that it is not a meningocele which has penetrated through the base of the skull.

Indications.—Simple or malignant polypi growing from the base of the skull that can be completely removed.

Special instruments.—Wire snare or polypus forceps, gag, nasal speculum, forehead mirror, bone forceps, periosteal elevator, Hey's saw, chisel and mallet, sponge-holders, and needles or handles.

Position.—The patient is placed in the dorsal posture, with a sandbag underneath the head. The surgeon stands on the right side of the patient, the chief assistant on the left.

Operation.—(*a*) Through the nose; (*b*) through the mouth; (*c*) after temporary resection of the upper jaw.

(a) Through the nose.—When the growth is small and has a distinct pedicle, it may be removed in the manner described for simple mucous polypi. The wire loop is passed along the inferior meatus of the nose, and, the mouth being held open with a gag, the surgeon with his left forefinger manipulates the loop round the attached portion of the tumour. The loop being tightened until it includes nothing but the pedicle close to its attachment to the bone, the base is torn away, and the tumour removed from the naso-pharynx by the fingers, working through the mouth. As hæmorrhage is rarely severe, it is unnecessary to pack the nose or naso-pharynx.

When the tumour has no definite pedicle, it cannot be treated by the above method—a more severe operation must be carried out for its removal; the best method is the following:—

(b) Removal through the mouth.—*Preliminary preparations.*—If the growth is a very large one, and has extensive attachments to the base of the skull, it is advisable to perform a preliminary laryngotomy and to plug the lower part of the pharynx.

Operation.—1. *Division of palate.*—The mouth being widely opened with a gag, a median incision is made through the uvula, extending forwards in the middle line of the palate as far as may be considered requisite for the extraction of the tumour. Usually it will be found necessary to prolong this incision for the entire length of the palate. The soft palate and the soft structures covering the hard palate having been completely divided, the periosteum and other structures covering the palatal processes of the palate and superior maxillary bones are peeled back as far as the gums with a periosteal elevator. Then with a chisel and mallet the exposed part of the hard palate is removed, together with the necessary part of the bony septum of the nose. The mucous membrane covering the upper surface of the hard palate is now divided, by which means the entire naso-pharynx is opened up.

2. *Removal of tumour.*—The base of attachment having been defined, the entire tumour is forcibly separated from the bone with a strong rugine. This part of the operation must be completed as quickly as possible.

3. *Arrest of hæmorrhage and closure of wound in palate.*—The hæmorrhage is often very severe, and may be fatal, unless it can be arrested by actual pressure upon the bone, or this failing, by packing the naso-pharynx with strips of antiseptic gauze.

The margins of the incision in the soft palate and the soft parts of the hard palate are brought together and fixed in apposition by the insertion of a series of sutures. In the case of vascular tumours it may be necessary to pack the naso-pharynx with tampons of gauze.

(c) **After partial resection of the upper jaw.**—The best method is by lateral rhinotomy or Moure's operation. The skin incision should be made from the inner end of the eyebrow along the side of the nose to the lower end of the internal cartilage where it is carried through the floor of the vestibule. A transverse cut may also be necessary, and should pass through the inner canthus of the eye and along the conjunctiva covering the lower eyelid. The skin, muscles, and periosteum are reflected from the front of the jaw and drawn outwards. The cartilaginous portion of the nose is detached from the pyriform aperture and turned inwards. The lacrymal sac is displaced from its groove. A quadrilateral piece of bone is removed, including the nasal bone, the ascending process of the maxilla with part of the lacrymal bone and the anterior wall of the antrum. In this manner a free exposure of the tumour is obtained and its removal can often be effected without sacrificing the orbital plate or palate, in which case the deformity after the operation is insignificant.

Exploration of the Maxillary Sinus (antrum of Highmore).—The Maxillary Sinus is situated within the interior of the body of the superior maxilla, and normally communicates by an aperture with the middle meatus of the nose.

Indications.—The sinus may require exploration for the following conditions :—

(*a*) Intractable suppuration, not amenable to ordinary treatment. Empyema of the antrum.

(*b*) Necrosis of part of its bony wall.
(*c*) Foreign bodies such as teeth and dental plugs.
(*d*) Polypi.
(*e*) New growths, simple or malignant.

Special instruments.—Periosteal elevator, small gouge or perforator, bone forceps, dental forceps, Volkmann's spoon.

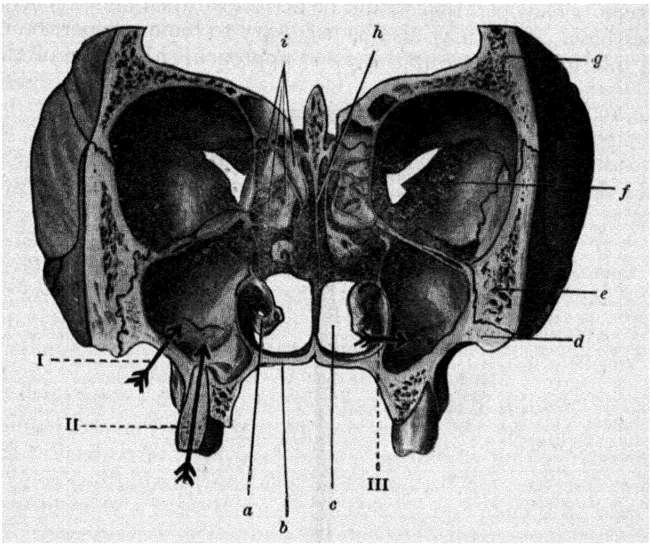

FIG. 257.—Drainage of the maxillary sinus : routes of surgical approach.

I. Through outer wall.
II. Through socket of tooth.
III. Through nose.
a. Inferior turbinate bone.
b. Palate.
c. Inferior meatus.
d. Outer wall of antrum.
e. Zygoma.
f. Cavity of orbit.
g. Frontal bone.
h. Nasal septum.
i. Ethmoidal cells.

Operation.—The maxillary sinus may be opened in the following situations :—

(1) From the nose.
(2) From the mouth.
    (*a*) Through the alveolus of a tooth.
    (*b*) Through the antero-external wall above the alveolus.

1. From the nose.—To confirm the diagnosis, the outer wall of the nose is perforated by a fine trocar and cannula immediately below the attachment of the inferior turbinate. If pus is found, an opening can be made in the same situation with a bone perforator under cocaine. Such an opening is large enough to allow the surgeon to irrigate with a small curved cannula until suppuration has ceased. In the majority of cases of recent inflammation such an operation gives very satisfactory results, but in old-standing suppurations a larger opening is often necessary, and can be made with burrs, hook knives, or bone forceps. The operation should be performed then under general anæsthesia, and it may also be necessary to remove a portion of the inferior turbinate if this bone approaches the floor of the nose. The mucous membrane lining the antrum need not be removed.

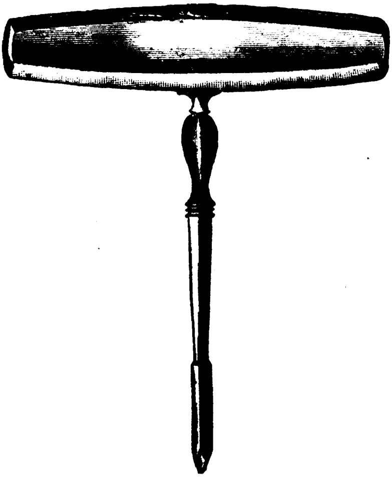

FIG. 258.—Antrum perforator.

After-treatment.—The cavity must be frequently washed out with lotions until the discharge has ceased. No plugging is necessary. If free drainage is maintained, the operation is attended with excellent results.

2. From the mouth.—(*a*) *Through the alveolus of a tooth.*—If the first or second molar or the canine tooth of the affected side is absent, a perforator is bored through the bone until the cavity of the antrum is reached. When all the teeth are present, the first or second molar should be extracted for the purpose of exposing the alveolus.

(*b*) *Through the antero-external wall.*—The upper lip having been everted, an incision is made through the mucous membrane and the periosteum, from the lateral incisor to the last molar tooth, in the line of reflection from the cheek to the gum. The periosteum is detached upwards and outwards nearly to the lower border of the infra-orbital foramen. The exposed portion of bone is now removed with a chisel and mallet, and the cavity of the antrum laid open.

This operation affords free exposure of the cavity, and enables the surgeon to perform any further manipulation which may be requisite, such as removal of polypi, foreign bodies, sequestrum, or a piece of growth for diagnosis. The mucosa should be thoroughly curetted, but it is not advisable to remove the entire lining of the antrum. A free opening should be made into the inferior meatus of the nose, as already described, through which drainage is maintained, afterwards closing the external incision with catgut sutures (Caldwell-Luc operation).

Drainage of the frontal sinuses.—The frontal sinuses are situated between the two tables of the vertical portion of the frontal bone in the region of the superciliary ridges. Their extent varies, and often they pass outwards as far as the external angle of the orbit, as can be shown by X-rays.

The treatment of infections of these sinuses is attended by many difficulties and dangers. By removal of the middle turbinate and the anterior ethmoidal cells it is generally possible to restore the infundibulum (intra-nasal drainage). The external radical operation is a more serious undertaking and should be reserved for those cases which cannot be relieved by intra-nasal treatment, namely :—

(*a*) Chronic purulent sinusitis with fever, persistent headache, or pain.

(*b*) Acute empyema of, or persistent discharge from, the fronto-ethmoidal cells which cannot be relieved by intra-nasal treatment.

(*c*) Recurring polypi produced by a fronto-ethmoidal discharge.

(*d*) Necrosis or fistula of the frontal sinus.

(*e*) Sinusitis associated with intra-cranial complications.

(*f*) Tumours of the frontal sinus.

Special instruments.—Periosteal elevator, chisel, mallet, bone forceps, and sequestrum forceps.

Position.—The patient is placed in the dorsal position. The surgeon stands at the side of the head which is to be operated upon, and the assistant opposite to him.

Operation.—The operation described by Killian is generally practised, and gives the best results. The eyebrows and skin of the supra-orbital region must be thoroughly cleaned. As the hairs of this situation grow very slowly, shaving is not advised. A curved incision is made in the line of the eyebrow, from the temporal end of the orbit to the root of the nose, then along the side of the nose, curving outwards below the inner canthus of the eye (Fig. 259, *a*). This incision divides all the soft structures down to the periosteum, including the supra-orbital vessels and nerve.

Periosteal incisions.—The soft parts having been retracted, two incisions are made—(1) Above the supra-orbital margin, from the outer end of the wound to the centre of the root of the nose (Fig. 259, *b*); (2) from a point external to the attachment of the pulley of the superior oblique muscle along the line of the original skin incision (Fig. 259, *c*). The periosteum is separated from the anterior surface of the sinus in an upward direction, and from the inferior aspect downwards, leaving intact the periosteum, which lies between the incisions. With the chisel and mallet the anterior bony wall of the sinus is completely removed. The mucous membrane is incised, and all the diseased tissues are carefully removed from the cavity. Working from above downwards with a gouge, the floor of the sinus is cut away, including the nasal process of the superior maxilla.

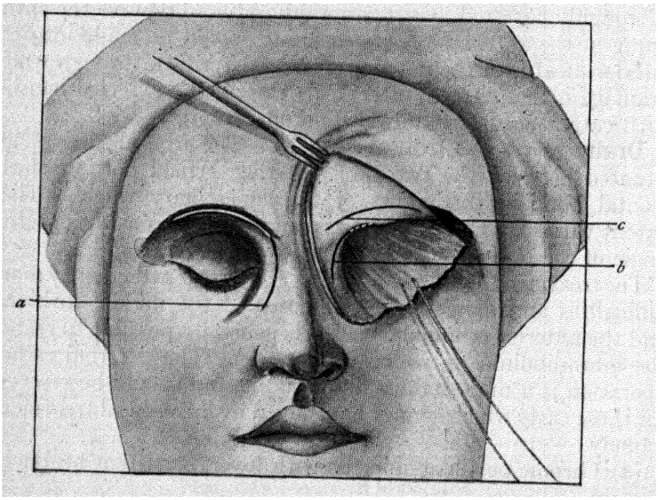

FIG. 259.—Position of incisions in Killian's operation.
a. Skin and soft parts. *b.* and *c.* Periosteal.

If possible, the attachment of the pulley of the superior oblique muscle to the orbit should be preserved. The nasal mucosa is freely opened, and the anterior portion of the middle turbinate cut away. A free communication with the middle meatus of the nose is thus established. The ethmoidal cells, if found to be diseased, must also be laid open. The whole wound is irrigated with lotion, and drained by gauze plugging, which is brought out through the nose, and by a small tube inserted in the outer angle of the supra-orbital incision. The soft parts may then be united with sutures. The external wound heals in about ten days, and owing to the preservation of a bridge of bone, as described above, the deformity is slight.

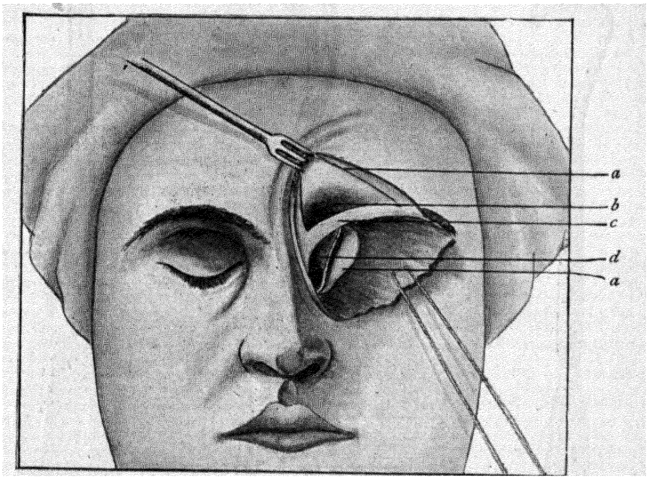

FIG. 260.—Bone removed in Killian's operation.

a. Periosteum. *b.* Posterior wall of sinus. *c.* Bridge of bone retained. *d.* Floor of sinus.

Removal of adenoid growths from the naso-pharynx.—It is advisable to observe caution in giving an anæsthetic to a patient in whom there is well-marked obstruction to breathing, and the laryngeal reflex should never be completely abolished. In young children, A.C.E. mixture is preferred ; in older children and adults, gas and oxygen is the best anæsthetic, provided that the surgeon is experienced in rapid execution of the operation.

Special instruments.—Curette, forceps, and sponge-holders.

Position.—The patient is anæsthetised and placed in the dorsal position, with the head turned to the right side. The surgeon stands at the right-hand side of the patient's head.

Operation.—The mouth being held open with a gag, the curette or special forceps (Figs. 261–263) is taken in the right hand and passed behind the soft palate into the naso-pharynx. The growths are seized by the forceps and forcibly avulsed, or scraped away with the curette. Care must be taken not to seize or to drag away with the forceps any part of the nasal septum, uvula, soft palate, or epiglottis. This operation is best completed by scraping away with the finger-nail whatever portions of the growths have been left behind. Hæmorrhage may be severe, but usually ceases after a short time, spontaneously.

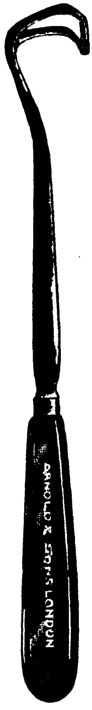

Fig. 261.—Gottstein's curette.

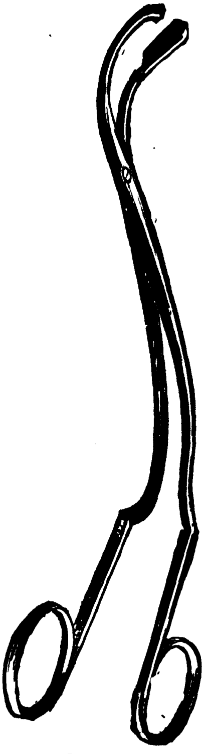

Fig. 262.—Adenoid forceps.

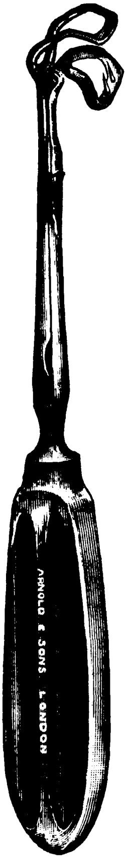

Fig. 263.—St. Clair Thomson's curette.

CHAPTER XIII

OPERATIONS UPON TONSILS

ABSCESS.
TONSILLOTOMY.
TONSILLECTOMY.
INNOCENT GROWTHS.
MALIGNANT GROWTHS.
  (1) Operation through mouth.
  (2) Operation through neck.

Anatomical position of the tonsil.—The tonsil is situated between the anterior and posterior pillars of the fauces at the side of the base of the tongue, and beneath the angle of the jaw. The internal carotid artery is ½ to ¼ inch behind and to its lateral side, and separated from it by connective tissue and that part of the deep cervical fascia which forms the carotid sheath.

Tonsillar or peri-tonsillar abscess.—Abscess in or around the tonsil is a common complication in acute inflammations which do not subside in a few days, but it frequently happens that very little pus is formed, and the surgeon may experience great difficulty in locating its position.

On this account incision with the knife is steadily becoming less popular. In most instances it is easier to evacuate an abscess by probing than with a scalpel. This is effected as follows :—

In order to minimise the pain, the surface of the tonsil is painted with a 10 per cent. solution of cocaine until the tissues are anæsthetised. A silver probe is then taken and bent in such a manner that half an inch projects at a right angle from its end. This is forced through the tonsil in various directions, upwards towards the palate, outwards towards the tonsillar fossa, and downwards near the anterior or posterior pillars of the fauces. The tonsil substance is so softened by inflammation that no difficulty will be experienced, and in many cases a passage may be effected through an enlarged crypt near the upper part of the tonsil. As soon as the abscess is pricked, the pus will escape along the probe, and the sinus so formed can easily be dilated with forceps. This operation can be repeated on the next day if necessary.

The above method, if properly carried out, is completely successful in relieving the patient and draining the abscess. If, however, an incision is preferred, the cut may be made with an ordinary tenotomy knife, around the blade of which strapping has been wrapped so that only half an inch of the cutting portion at the point is left bare.

The most prominent part of the swelling is chosen, the knife is bodily plunged into it at this point, and on withdrawing it it is made to cut upwards and inwards, thus dividing the arch of the palate in most instances. After the pus has been evacuated, the pharynx should be washed frequently with an antiseptic solution.

Tonsillotomy and Tonsillectomy.—There has been much discussion in recent years as to whether it is better to cut off part of the tonsil (Tonsillotomy), or to remove the whole gland with its capsule (Tonsillectomy) as a routine treatment.

The former is undoubtedly the easier operation to perform, and is less likely to be attended by serious complications. On the other hand, tonsillectomy is preferred by most of the present throat surgeons and gives better results in the following conditions:—

1. Recurring tonsillitis, or quinsy, which has not been cured by previous tonsillotomy.
2. Tonsils which are submerged.
3. Tonsillitis associated with enlarged glands in the neck.
4. Primary tuberculous tonsillitis.
5. Circumscribed neoplasms of the tonsil.

The anæsthetic.—In adults, removal of the tonsils can be effected either with local or general anæsthesia. If the former method is preferred, the tonsils should be painted with a 10 per cent. solution of cocaine immediately before the operation.

For tonsillectomy, which is more difficult with local anæsthesia than tonsillotomy, it is advisable to inject 1 per cent. solution of novocaine under the mucous membrane in four or five places around the tonsil.

Of general anæsthetics, gas and oxygen or ether are preferred for adults. In children a general anæsthetic must usually be given, and may be either ether, A.C.E., or ether and chloroform.

Position.—When operating under local anæsthesia, the patient should be seated in an upright position with an assistant standing behind to hold the head. With general anæsthesia the patient should be lying on a flat table on his right side, so that the blood passes into the cheek and there is no danger of suffocation.

Operation. — Tonsillotomy. — The assistant is directed to press the tonsil inwards and upwards by placing his finger on the skin immediately behind the angle of the jaw. The guillotine (Fig. 264) is passed into the mouth so that the tonsil protrudes through the aperture at its extremity. As much as possible should be removed by a sudden sharp cut. To prevent the tonsil slipping out of the instrument, the blade must be kept firmly pressed home until it is out of the mouth. Both tonsils can be removed simultaneously by use of a guillotine in each hand, but this is only necessary in the case of young children.

Operation.—Tonsillectomy.—This operation can be performed with a large variety of instruments, including the guillotine, knives, scissors, wire-snare, or finger, but the authors prefer the following method, because of its simplicity :—

The right tonsil is seized with a small curved volsellum (Fig. 265), and is drawn downwards and inwards so that a cut can be made with a pair of blunt, curved scissors, through the mucous membrane immediately under the arch of the fauces. One blade of the scissors is introduced under the mucous membrane immediately in front of the posterior pillar, and the membrane is then divided. The mucous membrane passing from the tonsil to the anterior pillar is divided in a similar manner. It is important that these three cuts should be made as superficial as possible in the direction of the tonsil, but not deep enough to divide its capsule. The tonsil can then be drawn in a downward direction, so that the white capsule which covers it at the upper part becomes visible, and at this stage the wire-snare should be passed over the volsellum and made to encircle the gland. By

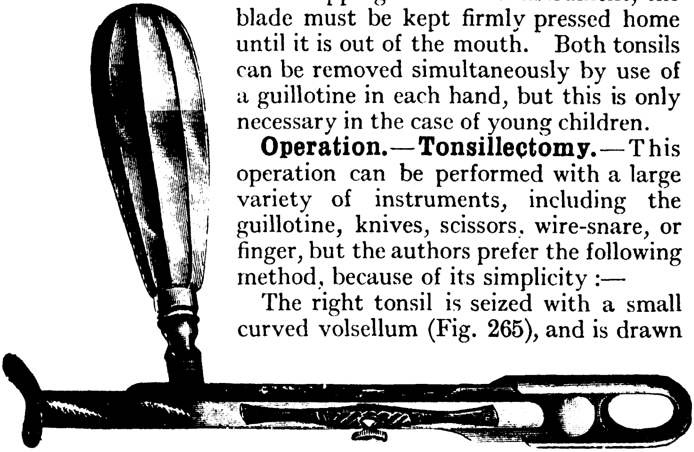

FIG. 264.—Mackenzie's tonsil guillotine.

tightening the wire the whole structure can be removed with its capsule, and in many instances with very little bleeding. If the preliminary isolation of the tonsil from the fauces has been properly carried out, no important structures will be damaged, but before tightening the snare it is essential to make certain that the uvula and the pillar of the fauces are not included. The wound is next examined carefully, and any bleeding points are seized with forceps and either ligatured or twisted sufficiently to stop hæmorrhage. No special after-treatment is necessary in the majority of cases.

Although recurrent and secondary hæmorrhage occur occasionally they are rarely dangerous, and the bleeding nearly always stops when the patient becomes faint. For desperate cases the cavity should be filled with gauze, which is fixed firmly in place by sutures passed through the pillars of the palate, rather than the more severe operation of ligature of the carotid artery, for cases are recorded in which the common carotid has been tied and the bleeding continued until the patient became faint.

Innocent growths.—The only common neoplasms are papillomata, which can be removed with scissors or galvano-cautery without difficulty. Occasionally it is better to remove a part of the tonsil.

Malignant growths.—The primary malignant growths which affect the tonsil are squamous-celled carcinoma, sarcoma, and endothelioma, the first being the commonest. They may be removed either by an operation similar to tonsillectomy, by diathermy, or through an incision through the skin of the neck. In some cases good results may be obtained by insertion of radium needles or by X-ray treatment.

1. Operation through the mouth.—*Special instruments.*—Blunt-pointed scissors, gag, volsellum forceps, and laryngotomy tube.

Position.—The patient is placed in the dorsal position, with the head supported by a firm pillow ; the surgeon stands on the affected side of the head, and his assistant opposite to him.

Preliminary laryngotomy.—In most cases it is advisable to perform a preliminary laryngotomy, and then to plug the upper aperture of the larynx with a marine sponge. This will prevent blood passing downwards into the respiratory passages.

Operation.—The angle of the mouth on the affected side is retracted, or in difficult cases it may be necessary to make an incision horizontally backwards, on the affected side, from the angle of the mouth to the anterior border of the masseter muscle.

The facial artery is cut across in this procedure, and its two ends must be secured and tied. The flaps of the cheek are held aside, and the tongue drawn forwards and to the opposite side. If necessary, a strong silk ligature is passed through the tongue and given to an assistant to hold, in order to exert traction when required. Usually, however, retraction with a suitable retractor will be sufficient.

The soft palate is divided well beyond the limits of the growth with the scissors, and the cut carried backwards into the walls of the pharynx, care being taken to make an incision some distance from the margins of the diseased tissues. The tonsil is next seized with volsellum forceps (Fig. 265) and dragged forwards, the tissues which attach it to the wall of the pharynx being cut through with the scissors. By this means the tonsil with the malignant growth is removed. In some cases of sarcomata it will be found that the growth shells out of a sheath. Unfortunately, however, in these cases recurrence is very prone to occur, and it is better to cut wide of the disease, if it can be done with safety, than to trust to shelling it out of the capsule of connective tissue. All hæmorrhage from the area of operation is arrested, and the margins of the incision in the cheek united by the insertion of a series of interrupted sutures. The laryngotomy tube can be taken out usually at the end of the operation.

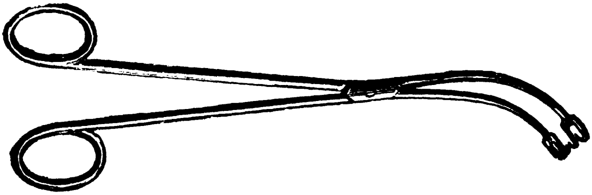

FIG. 265.—Volsellum forceps.

2. Operation by diathermy.—With small localised growths the disease may be destroyed by simple cauterisation with a button electrode. Large tumours can be excised freely after a preliminary laryngotomy. For such cases a small knife is used, and the tissues are coagulated before they are divided. In some instances it may be necessary to excise one-half of the tongue together with the tonsil. By the use of the cautery, hæmorrhage is reduced to a minimum, and it is rarely necessary to ligature any vessels.

3. Operation through an incision in the neck.—Several varieties of operation by this method have been proposed. The incision is made along the anterior border of the sterno-mastoid of the affected side, commencing above at the lobule of the ear, and extending downwards to the great cornu of the hyoid bone. In most cases it is necessary to remove a portion of the lower jaw, or at least to saw it through and turn it aside.

The tendency to early recurrence after all these operations renders the prognosis unfavourable. The best results are to be expected in those cases where the primary growth can be removed freely through the mouth, preferably by diathermy. In all cases the lymphatic glands must be widely removed by a later operation.

4. Insertion of radium needles.—The needles should be about 2 cm. long and contain 1 or 2 mgrms. of the radium salt each. They should be inserted into all parts of the growth at regular intervals, lying as far as possible parallel to one another. Each needle must have an attached silk, which is brought out of the angle of the mouth and secured by strapping on the side of the face. Usually, they are left *in situ* for four to seven days.

CHAPTER XIV

OPERATIONS UPON THE LARYNX AND TRACHEA

REVISED BY

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1. OPERATIONS UPON THE LARYNX.
   - Laryngotomy.
   - Thyrotomy.
   - Excision of the larynx, (1) complete.
   - ,, ,, (2) partial.
   - Intubation.
2. OPERATIONS UPON THE TRACHEA.
   - Tracheotomy. (1) High operation.
   - ,, (2) Low operation.
   - ,, (3) Median operation.

OPERATIONS UPON THE LARYNX

Laryngotomy.—The term "laryngotomy" is used to designate an operation which consists in establishing a communication between the interior of the larynx and the surface of the neck, through an incision dividing the crico-thyroid membrane.

(*a*) *Indications.*—Sudden impaction of a foreign body, such as a portion of food or a tooth-plate, in the upper aperture of the larynx.

(*b*) Some forms of disease of the upper part of the larynx, such as œdema due to trauma or the swallowing of hot fluids, in which the obstruction is only temporary.

(*c*) As a preliminary measure in some operations on the mouth, tongue, jaws, palate, tonsil, and pharynx, in order to prevent blood passing into the trachea, and to make the anæsthetic easier to administer.

Laryngotomy is usually an operation of emergency, since diseases of slow progress are rarely confined to the upper portion of the larynx. In children the operation is not advisable, owing to the small size of the crico-thyroid space.

Special instruments.—A sharp-pointed tracheal dilator, and laryngotomy tube.

Position.—The patient is placed in the dorsal posture, with a hard pillow underneath the neck, and the head projecting slightly over the end of the table; the surgeon stands on the right side of the patient, and his assistant directly opposite to him. If available, another assistant stands at the patient's head and steadies it, so that the chin, prominence of the thyroid cartilage, and suprasternal notch are maintained in a straight line.

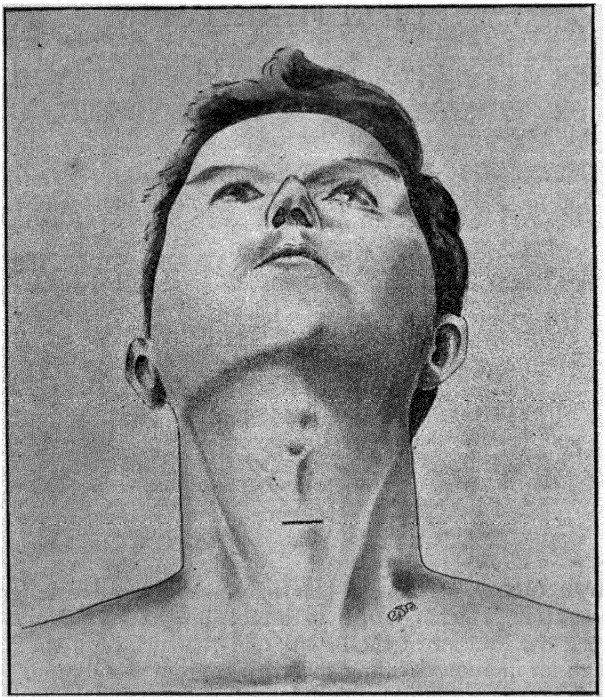


FIG. 266.—Laryngotomy. Position of patient, and line of incision.

Usually it will not be possible to give the patient an anæsthetic, owing to the urgency of the case, but whenever possible a solution of novocain (1 per cent.) should be injected into the subcutaneous tissues before the operation.

Operation.—The position of the cricoid cartilage is first defined, and a transverse incision 1 inch in length made immediately above the upper margin of the cricoid cartilage (Fig. 266). By pinching up a vertical fold of skin and transfixing it, the incision can be made more rapidly, and without injury to the anterior jugular veins. The deep fascia is divided so as to expose the interval between the two sterno-hyoid muscles. When these muscles are held aside with blunt hooks the upper border of the cricoid cartilage can be defined. The anterior surface of the crico-thyroid membrane will then be visible. The sharp dilator is taken in the right hand, its point placed exactly in the middle line, immediately above the cricoid, firmly stabbed into the larynx, and widely dilated so as to tear apart the mucous membrane.

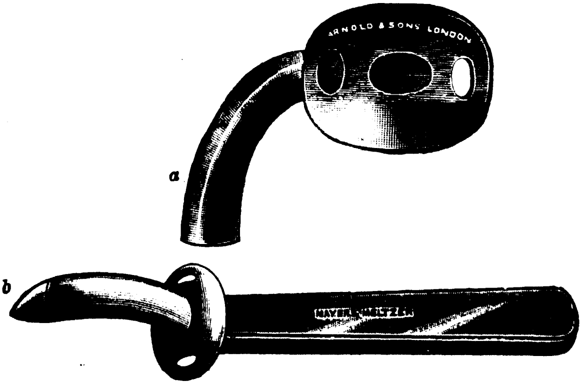


FIG. 267.—Laryngotomy.

a. Tube. *b.* Tube with introducer.—BUTLIN.

By opening the cavity of the larynx in this manner, there is less danger of wounding the crico-thyroid arteries. In cases of emergency, by transfixing the skin and immediately plunging the dilator between the sterno-hyoid muscles into the larynx, the whole operation can be performed in a few seconds. The dilator having been withdrawn, the laryngotomy tube is introduced and fixed in position with tapes. When laryngotomy is performed as a preliminary measure, the tube can be removed immediately after the completion of the main operation.

During the course of the operation all bleeding vessels are immediately seized with pressure forceps. No sutures are inserted, and the wound is dressed lightly, for fear of emphysema.

Thyrotomy.—The operation of thyrotomy consists in the division of the thyroid cartilage through an incision in the middle line of the neck.

Indications.—(*a*) Intrinsic malignant tumours of the larynx (carcinoma or sarcoma), when an early diagnosis has been made.

(*b*) Some disease of the larynx, such as suspected epithelioma, in which it is impossible for the surgeon to make an exact diagnosis by other methods.

(*c*) Simple laryngeal growths which cannot be satisfactorily removed by the endo-laryngeal methods.

(*d*) Some forms of stenosis following syphilis, trauma, and other rare forms of ulceration. The operation is seldom advisable for tuberculous laryngitis.

(*e*) *Foreign bodies.*—Thyrotomy is now rarely necessary, and should only be performed when it is impossible to remove the foreign body by means of a tube speculum (direct laryngoscopy).

Special instruments.—Sharp hooks, bone scissors (Waggett's), Volkmann's spoon, and ligature material (silk and catgut), and the instruments for tracheotomy.

Preliminary tracheotomy. — Before the performance of thyrotomy it is advisable to perform a preliminary tracheotomy, or this can be done five to ten days previously in cases with bronchitis which do not respond to the ordinary methods of treatment. In either case a sponge should be packed above the upper portion of the tracheotomy tube, or the trachea plugged with a tampon cannula (Hahn's), so as to prevent the passage of blood and particles of growth into the trachea.

Position.—The patient is placed in the dorsal posture, with the neck supported by a sandbag or a pillow, and near the end of the operation table. The operator stands on the right side of the patient, and the assistant opposite to him on the left.

Operation.—The operation should be carried out in four stages—

(*a*) *External incision.*—The thyroid cartilage is fixed between the thumb and forefinger of the left hand, and a vertical incision made in the middle line of the neck, commencing about ½ inch below the body of the hyoid bone, and extending downwards to the middle of the cricoid cartilage.

This incision divides the skin and fasciæ, and defines the interval between the two sterno-hyoid muscles. These muscles are separated with retractors, and the fascia in front of the thyroid cartilage divided.

(*b*) *Division of thyroid cartilage and opening of laryngeal cavity.*—With a scalpel a small vertical incision is made through the central portion of the crico-thyroid membrane. The inner blade of the bone forceps is inserted through this opening into the larynx, and carefully directed upwards between the vocal cords. When the whole length of the thyroid cartilage is included between the two blades the forceps are closed so as to divide it exactly in the middle line. This method of opening the cartilage is rapid and unlikely to destroy the anterior attachments of the vocal folds. The lateral alæ are drawn apart with retractors or sharp hooks, thus exposing to view the interior of the larynx. The pharynx is plugged with gauze in order to prevent saliva from running into the wound. Cocaine, 20 per cent., is freely applied to the interior of the larynx, to arrest oozing from the vessels, and to destroy the laryngeal irritability. It is advisable at this stage to plug the upper part of the trachea with a small sponge, attached to a piece of silk passed downwards between the vocal folds (if it has not already been done). If, however, the rima glottidis is much encroached upon by new growth this procedure is not possible.

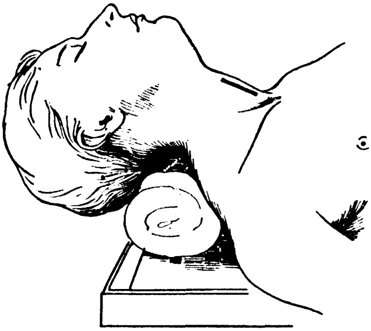


FIG. 268.—Thyrotomy. External incision.

(*c*) *Removal of diseased tissue, or foreign body.*—If the operation has been performed for the removal of a simple growth, this is removed either by dissection, or by careful cutting with a fine pair of scissors or a scalpel; or if for a localised squamous-celled carcinoma, this is dissected away, care being taken to cut through normal tissue well beyond the margins of the affection. The perichondrium should also be removed with the tumour, and the cartilage scraped absolutely bare with a Volkmann's spoon. In the case of ulceration the affected areas are well scraped, so as to remove all affected tissue, and in stenosis the fibrous tissue is very freely removed. When a foreign body is lodged in the recessus laryngis, it is extracted, if possible, through the opening of this space into the cavity of the larynx; or if this cannot be done, the mucous membrane over the most prominent point of the impacted body is incised, and then the extraction is performed.

If any arteries are cut across during the performance of the intra-laryngeal part of the operation, they are picked up with fine artery forceps, and ligatured in the usual manner.

(*d*) *Closure of the external wound.*—When all bleeding has been arrested, the two halves of the thyroid cartilage are brought together and fixed in apposition with one or two sutures of catgut. These sutures should be inserted as near to the free margins of the cartilage as possible, and should not traverse the cavity of the larynx. The cartilages are thus retained exactly in their original position. The infra-hyoid muscles are approximated with one or two catgut sutures in the upper part of the wound. Finally, the wound in the fascia and skin is closed by the insertion of several points of interrupted suture of silkworm gut.

After-treatment.—The tracheotomy tube is worn for several days after the operation. When the swelling of the mucous membrane of the larynx has subsided, the tube is removed, and the wound allowed to close by granulation. The tracheotomy tube can be removed usually at the end of a week.

The lymph glands are rarely affected in the earlier stages of intrinsic forms of cancer of the larynx, and dissection for their removal is not required.

Excision of the larynx, or laryngectomy.—Excision of the larynx may be either complete or partial. In the former case the entire organ is removed with all its cartilages, and in the latter only the portion involved in the disease, usually a lateral half, is taken away.

Indications.—Removal of the larynx is carried out for primary malignant tumours which involve (*a*) the whole of the interior of the larynx (intrinsic), or (*b*) a portion of the larynx, together with the wall of the pharynx (extrinsic), provided that the adjacent structures are not extensively involved.

Special instruments.—Sharp hooks, periosteal elevator, sponge-holders, tampon cannula, sponge plugs.

Preliminary thyrotomy.—Before attempting complete removal of the larynx, it is often necessary to open the thyroid cartilage, as described above, in order to confirm the diagnosis and explore the limits of the tumour. In rare instances a preliminary tracheotomy should be performed five to ten days before this operation. It is advisable to open the trachea below the isthmus of the thyroid gland—low tracheotomy—if possible, so that the tracheotomy tube will not be in the way during the operation, and sufficient room will be allowed for plugging the trachea above the tube.

Position.—The patient is placed lying upon the back near the right edge of the table. The shoulders are slightly raised, and a hard pillow placed underneath the neck. The operator stands on the right side of the patient, and his assistant on the left.

Operation.—*Removal of entire larynx.*—The positions of the hyoid bone, the thyroid cartilage, and cricoid cartilage are first defined. An incision is then made in the middle line of the neck, commencing at the lower border of the hyoid bone and extending downwards to a point immediately above the sternum. This incision divides the skin and fasciæ and exposes the surfaces of the cricoid and thyroid cartilages, the crico-thyroid and thyrohyoid membranes in the internal between the two sterno-hyoid muscles and the upper portion of the trachea. The isthmus of the thyroid gland is completely divided, and the upper poles of the lateral lobes are separated by blunt dissection. The trachea is divided transversely through the crico-tracheal membrane or one of the upper rings, care being taken not to wound the œsophagus which lies behind it. As this is being done the margins of the trachea are drawn forwards to prevent it from retracting towards the thorax. The stump of the trachea is then sutured with strong catgut sutures into the lower end of the original incision. A tracheotomy tube or tampon cannula is inserted into the trachea, through which the anæsthetic is continued while the operation is completed.

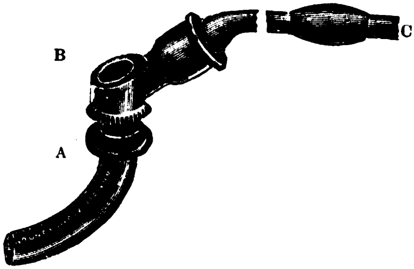


FIG. 269.—Excision of larynx. Gluck's phonation apparatus.

A. Tracheal cannula. B. Valve and voice piece. C. Tube to mouth.

The air-passages having been isolated in this manner, the removal of the larynx is greatly simplified.

The infra-hyoid muscles are strongly retracted, and if necessary a transverse incision made along the inferior margin of the body of the hyoid bone, dividing the sterno-hyoid muscles at their attachments. The thyro-hyoid and the sterno-thyroid muscles are separated with a periosteal elevator from the external surface of the thyroid cartilage. When the posterior part of the larynx is reached the attachment of the inferior constrictor muscle of the pharynx is separated from the cricoid and thyroid cartilages. As this is being done the crico-thyroid branches of the superior thyroid arteries will require ligature, together with any small muscular branches which may be met with. Next, the superior laryngeal branches of the superior thyroid arteries are secured, just before they pass through the thyro-hyoid membrane. Then the thyroid cartilage is pulled forward by an assistant, with sharp hooks, whilst the surgeon cuts through the median and lateral portion of the thyro-hyoid membrane immediately below its attachment to the body and large cornua of the hyoid bone. The lower end of the larynx is now hooked forwards and carefully dissected away from the œsophagus from below upwards. It is important not to drag upon the œsophagus, as this affects the depressor fibres of the vagus and causes severe shock which may be fatal. The final division of the pharyngeal mucosa in the region of the arytænoids should be ½ inch beyond the limit of the growth, which in some cases necessitates removal of the upper end of the œsophagus.

All bleeding points are ligatured. Whenever it is possible, the upper end of the œsophagus is brought upwards and accurately united to the pharynx in the region of the hyoid bone, so as to close completely the cavity of the pharynx. This is accomplished by a double tier of catgut sutures, and the line of union is afterwards supported by the apposition of the infrahyoid muscles.

The entire wound is next packed with tampons of absorbent gauze. Usually it is advisable to unite the upper portion of the skin incision with sutures, but the lower part should be allowed to close by granulation.

Gluck's operation differs from the above in the following details. A large rectangular flap is turned to one side so as to expose the anterior aspect of the larynx and trachea, and these are isolated as before. A transverse incision is made into the pharynx through the thyro-hyoid membrane, and a tracheotomy tube sutured into the upper opening of the larynx in such a manner that the air-passages are completely shut off. The larynx and any part of the pharynx which is diseased is then dissected away from above downwards, care being taken not to button-hole the œsophagus. The trachea is severed transversely as a final stage, and sewn into a transverse wound immediately above the sternum. The pharynx is repaired as in the former operation.

After-treatment.—The wound is kept as clean as possible by daily dressing and sponging. The patient is fed by means of an œsophageal tube until the wound has commenced to close up. A second operation for the removal of the lymph glands is generally advised.

When the external wound has sufficiently healed, the patient is fitted up with an artificial larynx, to enable him to articulate. Fig. 269 is a representation of an instrument which is used for this purpose.

Removal of part of the larynx.—The early stages of the operation are similar to those for complete excision.

A vertical incision is made down to the cartilages, and the soft tissues drawn well aside. Next, the thyroid cartilage is split in a vertical direction, and the interior of the laryngeal cavity examined. If the disease is found to be strictly confined to one-half of the organ, unilateral extirpation may be carried out.

A transverse cut along the lower border of the hyoid bone is made on the affected side, and the soft parts detached and peeled backwards as in complete excision.

When necessary, the cricoid cartilage can be split anteriorly and posteriorly and the affected half removed. If the epiglottis is diseased it may be split in a vertical direction, and the affected half removed along with the corresponding portion of the thyroid cartilage. If it is not necessary to do this, the line of separation is made along the ary-epiglottic fold of the diseased side.

In cases where hemi-laryngectomy is required the cervical lymph glands of the same side must also be removed.

Intubation of the larynx.—Intubation of the larynx is a bloodless operation, which has been introduced to replace tracheotomy in favourable cases. The operation is carried out by passing a metal tube into the laryngeal canal through the mouth; the enlarged upper end of the tube, when it has been introduced, rests upon the ventricular bands, and the lower extremity extends downwards into the trachea.

Indications.—(*a*) Laryngeal obstruction caused by diphtheria.

(*b*) Chronic stenoses of the larynx which are fibrous in character, and due to previous inflammation and ulceration.

(*c*) Rarely, for œdema of the larynx in which stenosis is likely to be temporary.

Special instruments.—A set of O'Dwyer's tubes, a gag, a tube introducer or intubator, an extubator, and a long piece of silk of moderate thickness.

Position.—The patient (if a child) is placed in the sitting position on the knee of a nurse, a towel being wrapped around the chest so as to enclose the arms. The assistant fixes the head with his hands, and holds the mouth open with the gag. The surgeon stands or sits directly in front of the patient.

Operation.—The mouth of the child is held open by the gag (Fig. 270, *c*), which is introduced and held in position by the assistant. A tube of suitable size is selected, the corresponding pilot is fixed on the intubator, the tube itself passed over the pilot, and a piece of silk passed through the aperture in the margin of the flange. Next, the surgeon passes his left forefinger into the child's mouth and hooks forwards the epiglottis. The intubator and tube are taken in the right hand, and the introduction of the tube is accomplished by passing it along the left forefinger until the upper aperture of the larynx is reached. The free extremity of the tube is pushed down-

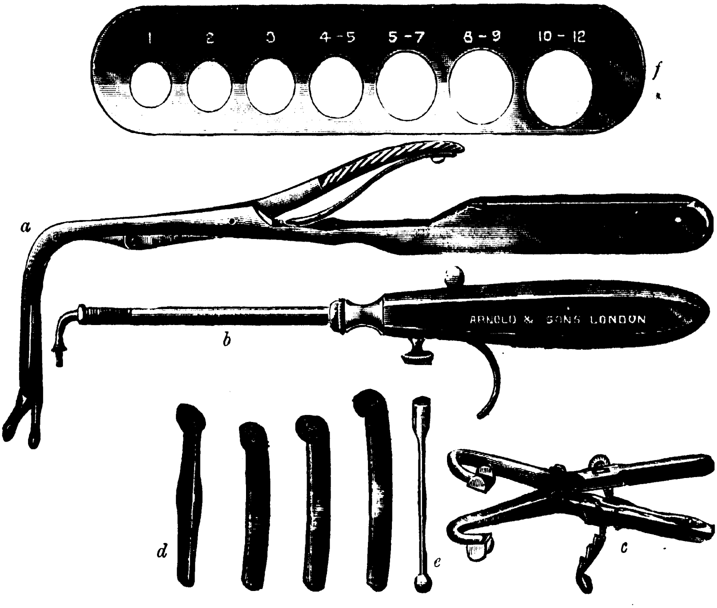


FIG. 270.—Intubation instruments.

a. Extubator.
b. Intubator.
c. Gag.
d. Intubation tubes.
e. Pilot.
f. Gauge.

wards until the finger at the upper part rests upon the ventricular bands, and the distal end reaches the upper part of the trachea. The tube is then detached from the intubator and the latter withdrawn. The piece of silk attached to the tube is fixed to the temporal region of the patient with a strip of strapping, and can afterwards be used for extraction of the tube. If this method is employed it is important to secure the hands of the child so that he cannot pull away the tube. It is safer to remove the silk after intubation is completed.

When changing the tube the child is held in the same position as before, and the distal end of the extubator (Fig. 270, *a*) is passed into the upper opening of the tube. The latter can then be removed.

OPERATIONS UPON THE TRACHEA

Tracheotomy.—In the operation of tracheotomy an artificial communication is made between the interior of the trachea and the surface of that part of the neck between the lower border of the cricoid cartilage and the suprasternal notch.

The cervical portion of the trachea consists of about eight rings, commences above at the lower border of the cricoid cartilage, and terminates below at the level of the suprasternal notch. The relations of the trachea to the surrounding structures are shown in Fig. 271.

The isthmus of the thyroid gland usually crosses the front of the trachea, opposite the second and third and occasionally the fourth rings. When the opening into the trachea is made above the isthmus of the thyroid gland, the operation is called " high " tracheotomy; and when below, the "low" operation; when the isthmus of the thyroid gland is divided, the "median" operation. The first is the one which is the more commonly performed, since it is less dangerous and is carried out more easily.

Operation of " high " tracheotomy.—*Indications.*—The operation of tracheotomy may be required in the following clinical conditions, namely:—

(*a*) Certain cases of laryngeal obstruction caused by diphtheria.

(*b*) Some forms of chronic ulceration of the larynx, where respiration is dangerously interfered with, such as syphilitic and epitheliomatous ulcerations.

(*c*) Cases of severe stenosis of the larynx dependent upon cicatrisation, or when the interior is filled up with proliferating rowths, such as papillomata.

(*d*) For the removal of foreign bodies from the trachea, or bronchi, in cases where upper bronchoscopy has failed.

(*e*) As a preliminary to the performance of some severe operations about the lower part of the pharynx and larynx.

(*f*) Rarely in tuberculous laryngitis, for the relief of dyspnœa.

Special instruments.—Blunt hooks, two-bladed tracheotomy dilator, tracheotomy tube and tapes.

Position.—The patient is placed in the dorsal position, with the head projecting slightly beyond the end of the operation table (Fig. 272). A sandbag is placed underneath the neck. The operator stands on the right side of the neck of the patient, the chief assistant opposite to him, the anæsthetist (if an anæsthetic is being given) controls the head, and a third assistant the body and legs of the patient.

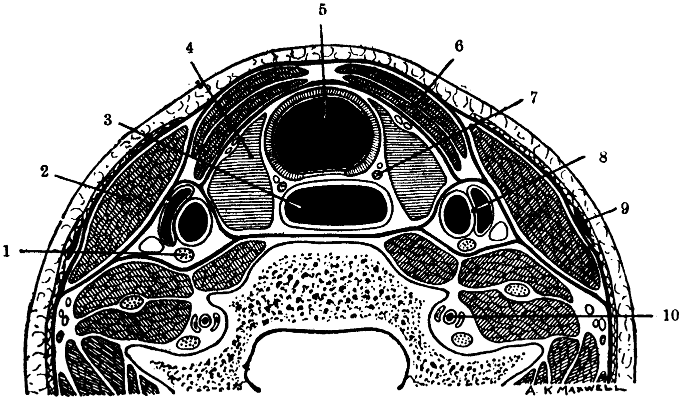


FIG. 271.—Transverse section of the neck at the level of the upper portion of the 7th cervical vertebra. (Seen from below.)

1. Vagus nerve.
2. Sterno-mastoid.
3. Œsophagus.
4. Thyroid gland.
5. Trachea.
6. Sterno-hyoid and sterno-thyroid muscles.
7. Recurrent laryngeal nerve.
8. Common carotid artery.
9. External jugular vein.
10. Vertebral vessels.

Operation.—The operation may be divided into three stages, namely:—

(*a*) *External incision.*—The head of the patient is so placed that the symphysis of the lower jaw, the prominence of the thyroid cartilage, and the suprasternal notch, are in a straight line corresponding to the middle line of the whole body; and throughout the operation this position of the head is maintained by the anæsthetist. If the head is allowed to deviate to one or other side the operation is more difficult, especially in young children. The cricoid cartilage is next defined, and grasped between the thumb and forefinger of the left hand, which grasp is not relaxed till the dilators are introduced into the trachea. The central point of the cricoid cartilage is taken, and an incision made vertically downwards from this point for 1½ inch, towards the centre of the episternal notch. In an adult with a fat neck it is necessary to make the incision longer. With the scalpel, the skin, superficial fascia, the anterior layer of the deep fascia are divided, and the space between the muscles opened. This space is lozenge-shaped, being limited externally by the sterno-hyoid muscles above, and by the sterno-thyroids below. The fascia in this interval is incised, and the muscles drawn aside with retractors or blunt hooks by an assistant. The pre-tracheal layer of the cervical fascia is next divided, and the anterior aspect of the upper rings of the trachea and the isthmus of the thyroid gland laid bare.

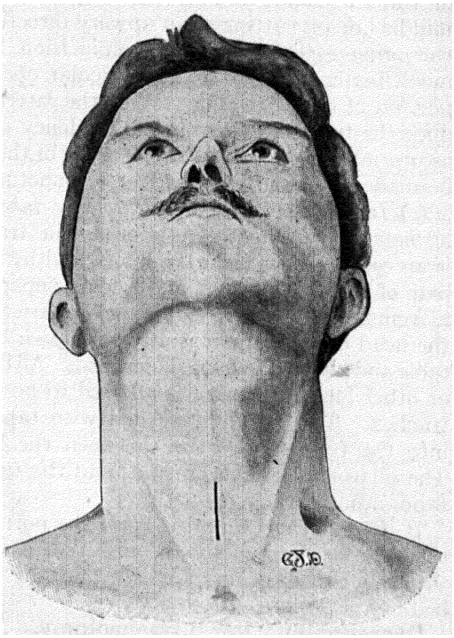


FIG. 272.—Tracheotomy. Position of patient, and line of incision in "high" operation.

(*b*) *Exposure and incision of the trachea.*—The isthmus of the thyroid gland is drawn downwards with a blunt hook, so as fully to expose the upper two or three tracheal rings. In order to facilitate this, it is sometimes advisable to divide the fascia transversely, immediately below the lower border of the cricoid. When the surface of the trachea has been thoroughly exposed, it is advisable to seize and ligature all blood vessels (usually veins) before an opening is made, and to prevent sepsis the whole wound should be treated with Bipp. The cricoid cartilage should be steadied by a blunt hook or with the finger and thumb of the left hand, and the trachea is opened precisely in the middle line by cutting in an upward direction through the upper three rings. This is the common incision, but if time allows it is much better to make a small circular opening by excision of a portion of only one ring. With the latter it is easier to introduce the tube and there is less tendency for septic discharge to escape into the wound. The opening of the trachea must always be made without force, for fear of puncturing the œsophagus.

(*c*) *Introduction of the tracheotomy tube, and partial closure of the external wound.*—As soon as the trachea is opened there is an escape of air from the lungs, and by inserting dilators or a pair of dressing forceps and widely separating the blades, the margins of the incision can be held apart. If bleeding is severe, the head of the patient is at once drawn beyond the end of the table and allowed to hang downwards. All diphtheritic membrane or other loose substance is allowed to be coughed out from the trachea. The tube is threaded with tapes, and then inserted into the tracheal aperture between the blades of the dilator. The dilator is now withdrawn, and the tube fixed by tying the tapes around the neck.

If the external wound is large the portions above and below the tube are united by the insertion of one or two points of suture. Dressings are applied, and the patient sent back to bed.

Operation of "low" tracheotomy.—This operation is occasionally necessary in severe dyspnœa, dependent upon compression of the trachea by malignant enlargement of the lymph glands of the neck, or an enlarged thyroid gland (rare). It is performed as a preliminary operation in laryngectomy, and rarely for foreign bodies impacted in the bronchi.

The operation only differs from the "high" operation in the position of the external incision, and the greater depth to which the dissection has to be carried. The incision is usually 3 inches in length, or even more ; it commences below the cricoid cartilage and extends to the upper border of the suprasternal notch. The same muscles are separated, the thyroid isthmus is pulled upwards instead of downwards, whilst the inferior thyroid veins and the thyroidea ima artery (when present) have to be dealt with.

In young children, if this operation has to be performed, the point of the scalpel must not be allowed to extend into the thorax behind the manubrium sterni, otherwise the innominate artery or the left innominate vein may be injured. The upper portion of the thymus gland may cover this part of the trachea and require to be drawn aside.

"Median" tracheotomy.—In this operation the isthmus of the thyroid gland is completely or partially divided. An incision, 1 inch in length, is made immediately below the cricoid cartilage, and repeated without any attention to the bleeding until the trachea is reached. The trachea having been opened in the usual manner, dilators are introduced and the patient drawn beyond the end of the table, so that the head hangs downwards. The bleeding ceases in a few moments, and the tube is inserted. This operation is performed entirely by the sense of touch, and no retractors are used. With an incision exactly in the middle line it is impossible to miss the trachea. Though attended with greater difficulties, the method is more rapid and capable of saving life if well carried out.

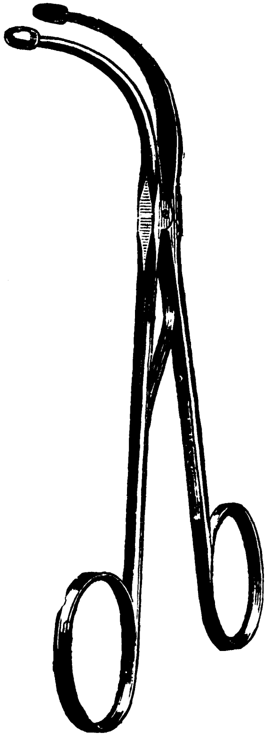


FIG. 273.—Tracheal dilators.

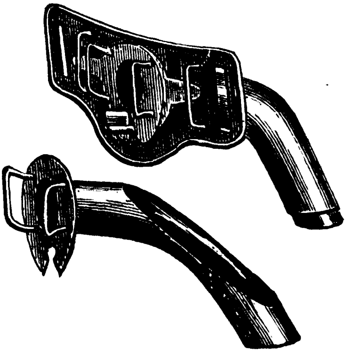


FIG. 274.—Tracheotomy tube.—PARKER.

CHAPTER XV

OPERATIONS UPON THE EAR

BY

C. ERNEST WEST, *Consulting Aural Surgeon, St. Bartholomew's Hospital*

EXTRACTION OF FOREIGN BODIES, OR RETAINED CERUMEN, FROM THE EXTERNAL AUDITORY MEATUS.

REMOVAL OF GROWTHS FROM THE EXTERNAL AUDITORY MEATUS—
- (*a*) Polypi.
- (*b*) Exostoses.

INCISION OF MEMBRANA TYMPANI.

EXPLORATION OF MASTOID ANTRUM AND CELLS.

RADICAL MASTOID OPERATION.

Extraction of foreign bodies, or retained cerumen, from the external auditory meatus.—It frequently happens that foreign bodies require extraction from the external auditory meatus. This is especially the case in young children.

Special instruments.—Aural syringe, speculum, forehead mirror, aural scoop, long thin-bladed forceps, and blunt rectangular hook.

It is not usually necessary to give an anæsthetic in these cases, except when young and refractory children have a foreign body tightly impacted in the auditory canal. In the latter case the administration of an anæsthetic will facilitate the removal of the impacted substance, and diminish the risk of damaging the adjacent parts of the auditory apparatus during the operation.

Operation.—The patient should be seated in a chair in a good light, or, if artificial light is used, it should be behind the affected ear, the surgeon using a mirror attached to his forehead for illumination.

The position and the nature of the foreign body, or plug of retained cerumen, is first made out by examining the meatus through a speculum. An attempt should always be made to remove the substance by syringing, and use of other instruments should be made with great caution. A foreign body will often remain indefinitely in the meatus without causing damage, while laceration of the membrane and meatus is a frequent result of attempts to extract instrumentally. Warm water or any dilute lotion may be used in the syringe. The nozzle of the syringe should be directed slightly upwards and backwards, so that the stream of fluid may pass in along the upper wall of the meatus and back along the floor. If this is done carefully it will suffice, in the majority of instances, for the removal of plugs of cerumen, or loosely situated foreign bodies. The object of directing the stream upwards and backwards is to ensure the fluid passing internal to the slight prominence which is normally met with

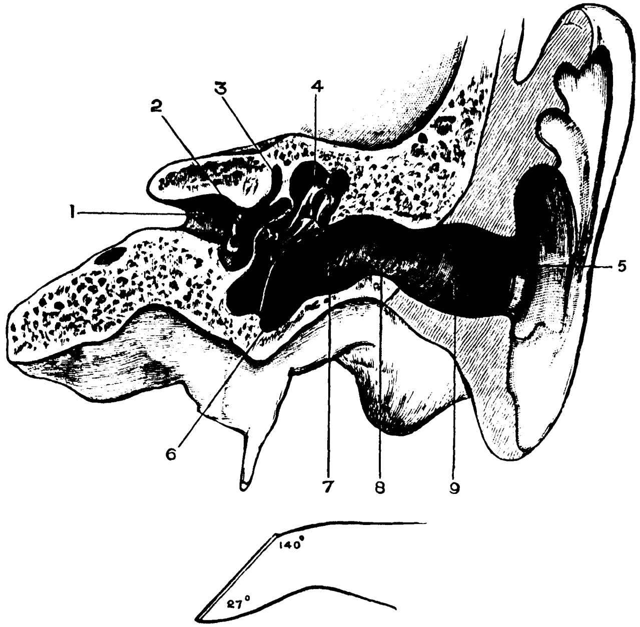


FIG. 275.—Vertical section through ear.—HUNTER TOD.

1. Internal auditory canal.
2. Labyrinth.
3. Semicircular canals.
4. Incus and malleus.
5. Concha.
6. Sinus of external auditory canal.
7. Bony meatus.
8. Narrow part of meatus.
9. Cartilaginous meatus.

on the floor of the canal and along the concave surface of the deeper part of the postero-superior aspect of the meatal wall. If syringing fails, an attempt should be made to pass the blunt hook beyond the substance and apply gentle traction.

If the foreign body cannot be removed in either of these ways, the auricle should be pulled upwards and backwards, and attempt made to pass the "ring scoop" (Fig. 278) beyond the impacted substance, and to extract it by pulling outwards. Usually this manœuvre will succeed when the other methods have failed. When the obstruction has been removed, the auditory canal is syringed clean, dried, and a small

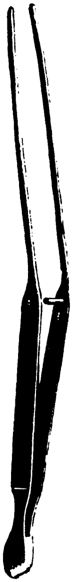


FIG. 276.—Aural forceps.—CUMBERBATCH.

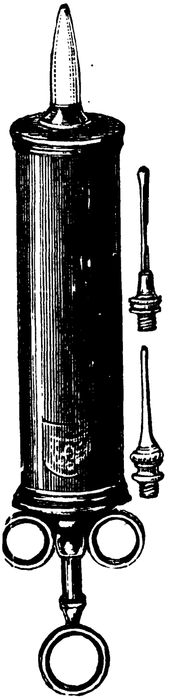


FIG. 277.—Aural syringe. Three forms of nozzle are illustrated.

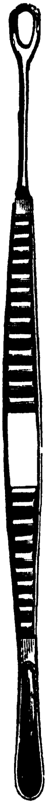


FIG. 278. — Aural scoop, for removal of foreign bodies from the external auditory meatus.

plug of wool placed in the meatus. When there is inflammatory swelling of the meatus so that a foreign body is embedded or imprisoned, or when all other methods of extraction have failed, the pinna must be turned forwards by an incision along the post-auricular furrow, and the cartilaginous meatus detached posteriorly. After removing the foreign body, the wound is sutured and the meatus lightly packed with a gauze-wick.

Removal of growths from the external auditory canal.—(*a*) *Polypi.*—In almost all cases polypi come through a gap in the membrana tympani, and have their origin in the mucous membrane lining the tympanic cavity, attic, and antrum. Occasionally they spring from the surface of an ossicle which is the seat of a local caries; rarely they are granulomata growing from the exposed surface of the inflamed dura mater, or are actually examples of hernia cerebri. Polypi growing from the outer surface of the membrane or from the meatal wall are excessively rare.

In structure a true aural polypus consists essentially of œdematous submucosa, more or less completely invested by a layer of columnar or squamous cells. The soft bright-coloured granulomata are merely large pedunculated granulations.

Special instruments.—As for the preceding operation, with the addition of an aural snare and aural probe.

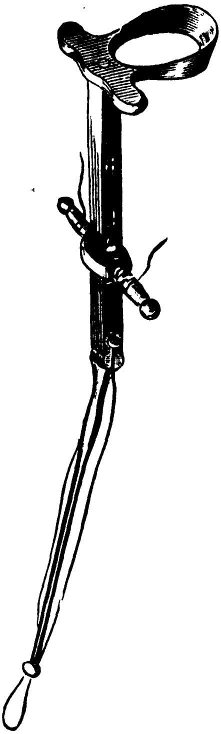


Fig. 279.—Wire snare for removal of polypi from external auditory meatus or tympanic cavity.

Operation.—The external auditory canal should first be syringed out with a dilute antiseptic solution, and then the nature of the growth and its point of attachment made out. The aural snare (Fig. 279) is next taken, and its wire loop passed around the tumour until the attached portion or pedicle is surrounded. The wire is then tightened until the pedicle is constricted. If the growth is attached to the wall of the canal, or to the membrana tympani, a sharp pull is made on the snare, by which means the polypus together with its attachment is forcibly pulled away. If, however, it is attached to the mucous membrane of the tympanic cavity, the wire loop should be gradually tightened until the pedicle has been cut through. The polypus is then removed. When the growth has the latter-mentioned attachments it is not advisable to remove it by forcible avulsion, otherwise one or

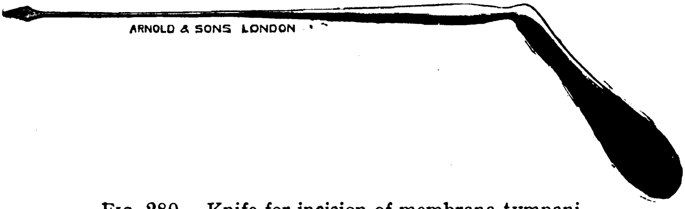


FIG. 280.—Knife for incision of membrana tympani.

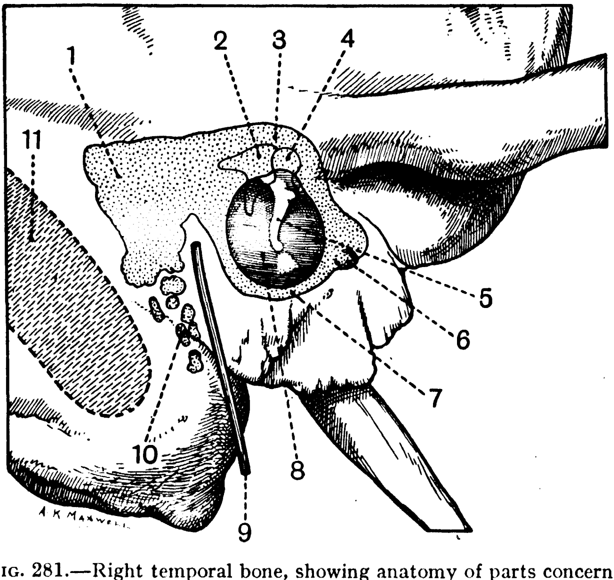


FIG. 281.—Right temporal bone, showing anatomy of parts concerned in mastoid operation.

1. Antrum mastoideum.
2. Incus.
3. Recessus epitympanicus.
4. Malleus.
5. Handle of malleus.
6. Anterior extremity of tympanic ring.
7. Tympanic ring.
8. Tympanic membrane.
9. Route of seventh cranial nerve.
10. Mastoid air cells
11. Lateral sinus.

more of the small bones of the tympanum may be removed along with it.

When the polypus has been removed, the auditory canal is syringed out, dried, and then examined through the speculum. If any other growths are discovered, they are removed in a similar manner. In the case of very small polypi, it may not be possible to get hold of them with the snare. In this case they should be destroyed with a saturated solution of chromic acid.

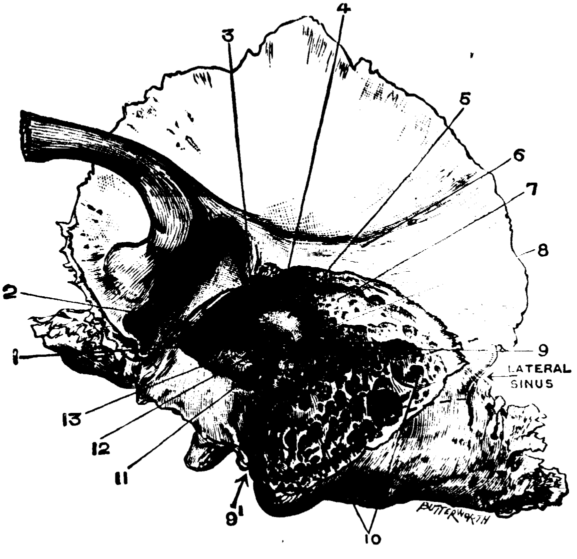


FIG. 282.—The anatomy of the bony middle ear and mastoid process. HUNTER TOD.

1. Anterior wall of external meatus partially removed.
2. Canal for tensor tympani muscle ending in process cochleariformis.
3. Attic.
4. Aditus.
5. External semicircular canal.
6. Posterior root of zygoma.
7. Tegmen tympani.
8. Antrum.
9. Fallopian canal for facial nerve.

9^1. Stylo-mastoid foramen.

10. Mastoid cells.
11. Fenestra rotunda.
12. Fenestra ovalis.
13. Promontory.

(*b*) *Hyperostoses.*—Hyperostoses of the external auditory canal occasionally occur. They chiefly affect the floor and the posterior wall, and take the form of convex bosses of compact bone continuous with the tympanic plate. No attempt should be made to remove them, unless they are giving rise to severe symptoms, owing to complete blocking of the external auditory canal. If removal is decided upon, the hyperostosis should be carefully chiselled away, either through the meatus or after reflecting the pinna. The operation is a very difficult and critical one, as the deeper margins of the base of the hyperostosis are close to the attachment of the membrana tympani.

True *exostoses* also occur occasionally. They are irregular masses of cancellous bone, usually attached to the outer edge of the tympanic plate, and are easily detached with the chisel. They are of inflammatory origin.

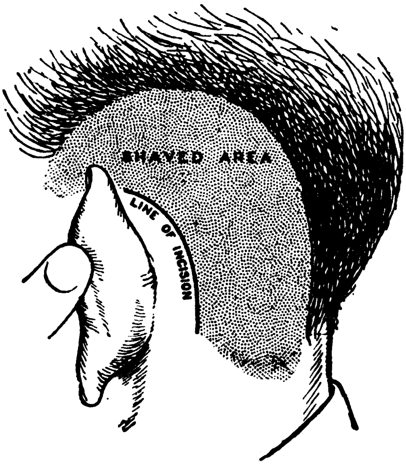


FIG. 283.—Line of incision for mastoid operation.—HUNTER TOD.

Incision of the membrana tympani.—*Indications.*—This operation may be necessary in the following conditions :—

In the course of an acute otitis media :—

(*a*) Continued pain, fever, and bulging of the membrane.

(*b*) Symptoms of early mastoiditis.

(*c*) Intense toxæmia even where the membrane is not strongly bulged.

(*d*) At the earliest possible moment in scarlatinal otitis.

It may also be indicated in more chronic conditions for the enlargement of an existing perforation, and the provision of better drainage.

Special instruments.—Aural speculum, forehead mirror, special knife, long, thin-bladed aural forceps.

Position.—The patient and operator are seated as for the removal of a foreign body.

Operation.—The external auditory canal is syringed out so as to remove all secretion, and then dried with plugs of wool. The speculum is introduced, and the most bulging portion of the membrane ascertained. The knife (Fig. 280) is passed through the speculum, and a free incision made through the bulging portion of the membrane, and carried from bottom to top of the membrane. If the operation is done for the evacuation of a collection of pus, this will at once exude.

Exploration of the mastoid antrum and cells.—On account of the close communication which exists between the air-containing spaces within the mastoid process (mastoid antrum and mastoid cells) and the tympanic cavity, and the frequency with which the latter space is the seat of suppurative affections, it often happens that the surgeon is called upon to explore the interior of the mastoid owing to an extension of the suppurative process from the tympanum.

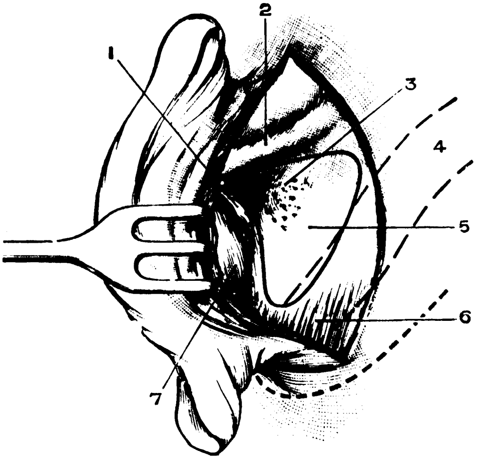


FIG. 284.—Surgical anatomy of Schwartze's operation.—HUNTER TOD.

1. Spine of Henle.
2. Posterior root of zygoma.
3. Vascular area over roof of mastoid : the usual position of a fistula.
4. Position of lateral sinus.
5. Area of bone removed in Schwartze's operation.
6. Mastoid process, with fibres of sterno-mastoid.
7. Fibrous portion of posterior wall of external auditory canal.

There are two recognised operations of major importance on the mastoid—Schwartze's and the " Radical operation."

Schwartze's operation.—*Indications.*—

(*a*) Mastoid abscess in cases of recent acute otitis media.

(*b*) Suppuration in the mastoid antrum or cells, indicated by pain, tenderness, and later, swelling. In these cases there is often little or no swelling until the pus has perforated the bone, and a small subperiosteal abscess has formed. The temperature is

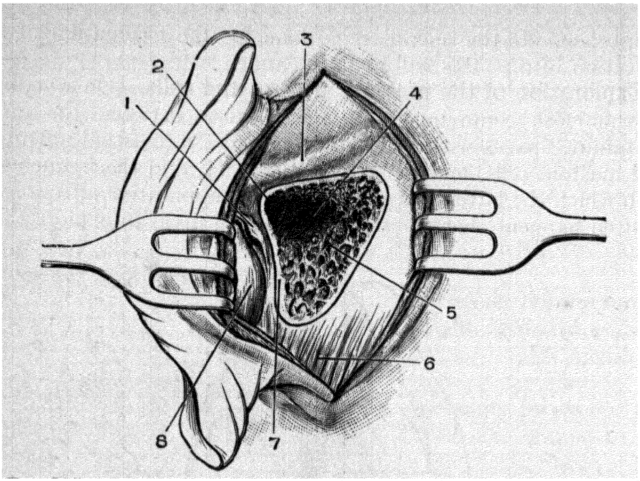


FIG. 285.—Schwartze's operation—simple opening of the antrum and mastoid.—HUNTER TOD.

1. Spine of Henle.
2. Aditus leading to tympanic cavity.
3. Posterior root of zygoma.
4. Antrum.
5. Mastoid cells.
6. Mastoid with fibres of sterno-mastoid.
7. Posterior wall of external auditory canal.
8. Fibrous portion of external auditory canal.

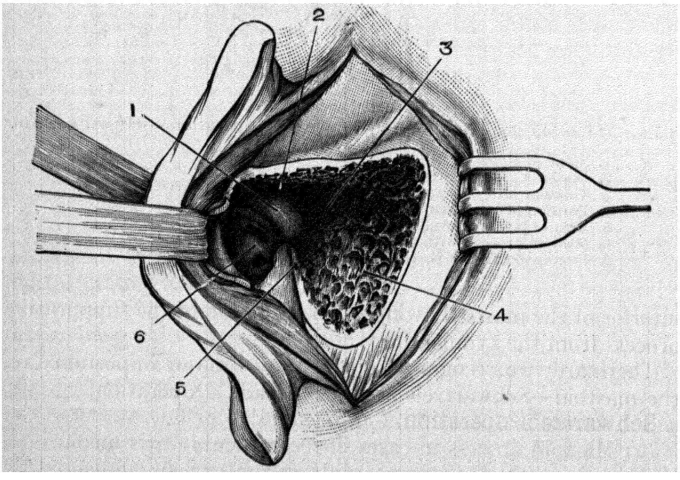


FIG. 286.—The radical or complete mastoid operation.—HUNTER TOD.

1. Semicircular canal.
2. Attic and tegmen tympani.
3. Antrum.
4. Cells.
5. Ridge of bone between the mastoid and tympanic cavities.
6. Inner wall of tympanic cavity.

often very slightly raised, and cannot be trusted as an indication of the condition of the interior of the mastoid. Schwartze's operation may form a preliminary to an exploration of the cranium for extradural abscess ; it should never be used except in recent suppurations. In all chronic cases of discharge the proper operation is the Radical.

Special instruments.—Gouge, mallet, periosteal elevator, small Volkmann's spoon.

Position.—The patient is placed in the dorsal position, with a pillow under the head, and the head turned towards the sound side. The surgeon stands on the affected side, and his assistant at the head of the table.

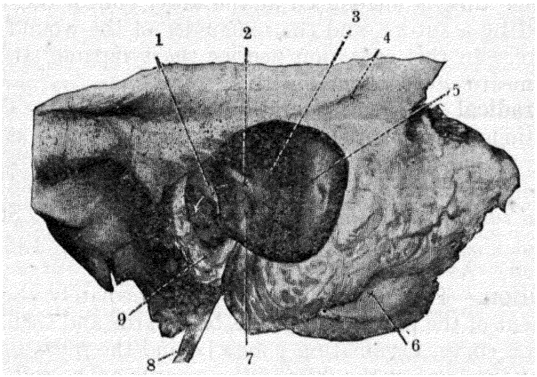


FIG. 287.—A deep dissection of the tympanic antrum and the petro-mastoid part of the temporal bone from the outer side. The arrow is passing through the aditus from the tympanic antrum into the tympanic cavity.—ROBINSON.

1. Remains of posterior wall of external meatus.
2. Lateral semicircular canal.
3. Posterior semicircular canal.
4. Temporal ridge.
5. Wall of groove for sigmoid part of transverse sinus.
6. Mastoid notch.
7. Wall of canalis facialis.
8. Styloid process.
9. Tympanic plate.

Operation.—An incision a little over 2 inches in length is made parallel with and immediately behind the free border of the auricle, commencing above and terminating near the apex of the mastoid process (Fig. 283). This incision divides everything down to the bone, including the periosteum. Some small branches of the posterior auricular artery will usually require ligature. Next, the soft tissues are lifted up from the bone with a periosteal elevator, as far as the posterior border of the meatus, and backwards for a short distance if necessary. The assistant pulls the auricle well forwards, and at the same time retracts the margins of the incision. The operator next takes the chisel and mallet, and removes the external table of the mastoid process, the portion of bone removed corresponding to 5 in Fig. 284.

The excavation in the bone is deepened in a direction inwards and forwards in its upper part, until the antrum is opened. In doing so the posterior wall of the meatus is to be carefully preserved. All the mastoid cells are now to be thoroughly opened up, every recess explored, and all softened bone removed. A drainage tube is introduced at the lower end of the wound, and fixed by a suture, and the remainder of the wound closed by suture. In this operation neither the tympanic structures nor the meatus are interfered with.

The radical mastoid operation. — *Indications.* — Chronic suppurations which resist less drastic treatment; and as a preliminary to operations on the lateral sinus, for brain abscess, and on the labyrinth.

Special instruments.—As for Schwartze's operation. Stacke's guard.

Position.—As for Schwartze's operation.

Operation.—The incision commences immediately above the attachment of the pinna, and passes backwards and then downwards in a curve, terminating ¾ inch behind the retro-auricular furrow at the level of the floor of the meatus. The soft tissues and periosteum are elevated forwards, and the meatus detached posteriorly. The antrum is opened as in Schwartze's operation. Stacke's guard is then passed through the auditus forwards into the tympanum. The posterior wall of the meatus is now removed with the gouge, the guard protecting the facial nerve from injury. The cavity in the mastoid and the tympanic space are thus laid into one. The cartilaginous meatus is now remodelled. The tenotome is passed along the meatus, and is made to cut outwards along the floor, and is then carried upwards just outside the margin of the concha to the level of the roof of the meatus. The flap so formed is held back and the skin dissected from the soft parts, which are cut away. The skin-flap may either be sutured to the deep surface of the tissues behind the ear, or be retained in position by packing. The original incision is closed by interrupted sutures, and the cavity lightly packed with gauze.

CHAPTER XVI

OPERATIONS UPON THE TONGUE AND SUBMAXILLARY SALIVARY GLAND

REMOVAL OF A PORTION OF THE TONGUE—
1. One lateral half.
2. A " wedge-shaped portion."

EXCISION OF THE ENTIRE TONGUE—
1. Through the mouth.
2. With median incision of the lower lip and division of symphysis of the lower jaw.
3. With lateral division of the cheek, and division or resection of the lower jaw.

REMOVAL OF THE SUBMAXILLARY SALIVARY GLAND.

REMOVAL of the tongue, either partial or complete, may be carried out through the oral aperture, through an incision in the submaxillary or submental regions, or after division of the cheek and resection of a portion of the lower jaw on one side.

The best method of administration of an anæsthetic to a patient upon whom an extensive operation upon the tongue and adjacent parts is to be carried out is the intra-tracheal method. In my experience, in the hands of a competent administrator, nitrous oxide gas, and oxygen, together with a limited amount of ether, is the best method of anæsthetisation during operations of this kind. After the intra-tracheal tube has been introduced, the lower portion of the pharynx can be plugged with a marine sponge, which will serve to absorb any blood which may collect in the pharynx and prevent it from being drawn into the trachea and lungs via the larynx. Figs. 288 and 289 illustrate a form of catheter and catheter introducer which is most useful during the administration of an anæsthetic by the intra-tracheal method. Other surgeons first perform a preliminary laryngotomy and then plug the upper portion of the pharynx with a sponge in the manner already indicated. In the past, some surgeons have preferred first to perform tracheotomy and then insert a Hahn's or Trendelenburg's tracheotomy tube. Laryngotomy, however, is an easier operation to perform and gives rise to less after-disturbances. In my view, however, insertion of an intra-tracheal tube via the pharynx and larynx—in some cases via the nose—and anæsthetisation with nitrous oxide, gas and oxygen, supplemented by ether, is the best method, since it gives all the advantages of tracheotomy and there is not the disadvantage of a laryngotomy wound to heal. Administration of the anæsthetic by an intra-tracheal tube, combined with plugging the pharynx with a marine sponge, prevents the passage of blood and facilitates the administration of the anæsthetic, and also enables the anæsthetist to keep well out of the way of the operator and his assistant. The introduction of an ordinary laryngotomy tube does not cause so much injury to the larynx or trachea as when either Hahn's or Trendelenburg's tubes are used.

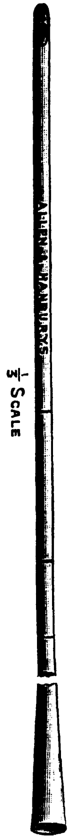


FIG. 288.—Intra-tracheal catheter.

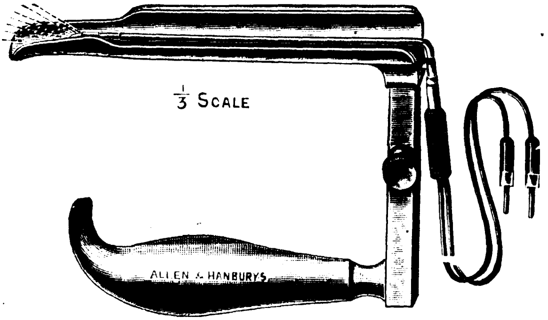


FIG. 289.—Catheter introducer for intra-tracheal anæsthesia.

Much assistance may be gained during the performance of operations on the tongue or the floor of the mouth by the use of a suction apparatus for removing fluid, such as is illustrated in Fig. 290. The tube (i) in Fig. 290 is passed into the cavity at the back of the tongue or the cavity of the pharynx. The continuous suction which is exerted by the motor removes blood from the cavity of the pharynx and so prevents it being drawn into the trachea and lungs.

Indications.—(*a*) Carcinoma of the tongue which admits of complete local removal, and in which there is not too extensive involvement of lymph glands by secondary growths. It may be considered advisable in some cases to remove the disease within the mouth, although there are numerous and extensive secondary

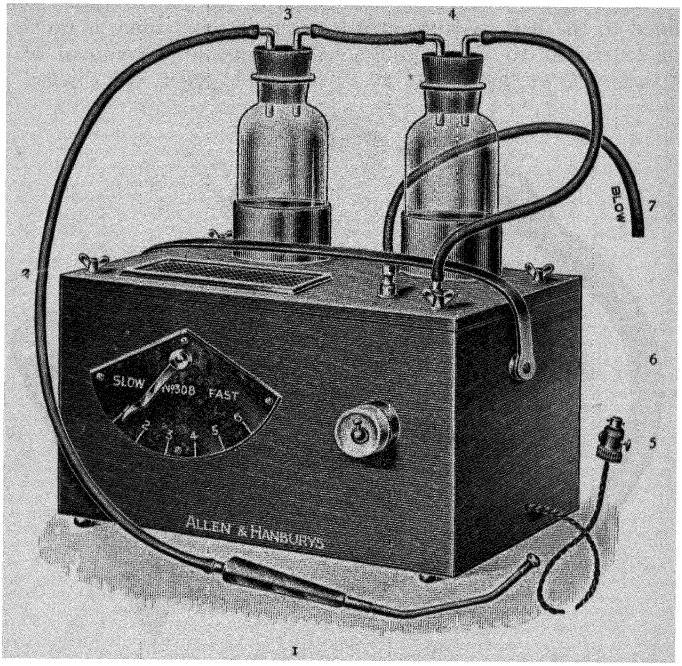


FIG. 290.—Suction apparatus for removing fluid—blood, etc.—from a space, such as abdominal cavity, pharynx, bottom of a deep wound, etc., during an operation.

1. Suction tube.
2. Rubber tube connection to the receptacle which receives fluid extracted.
3. Glass bottle for reception of extracted fluid.
4. Intercepting bottle.
5. Plug and flexible wire for connection between source of electric current and electric motor.
6. Box containing electric motor for exhaust vane.
7. " Blow " tube.

growths, in order to diminish the likelihood of the occurrence of inhalation septic pneumonia, and to make the patient's condition somewhat more comfortable. Early diagnosis of carcinoma of the tongue is extremely important, since the sooner cases are submitted to surgical treatment the greater are the prospects of a complete recovery, and freedom from recurrence, either locally or in the lymph glands in the neck. In addition, nearly all early cases can be successfully treated by partial excision. Removal of *one lateral half* of the tongue should be recommended in those cases in which the malignant disease is absolutely confined to the half it is proposed to remove, and there is no sign of extension to the fibrous median septum. Removal of a "*wedge-shaped piece*" is only permissible when the disease is of quite recent development, and is entirely limited to the lateral margin of the tongue.

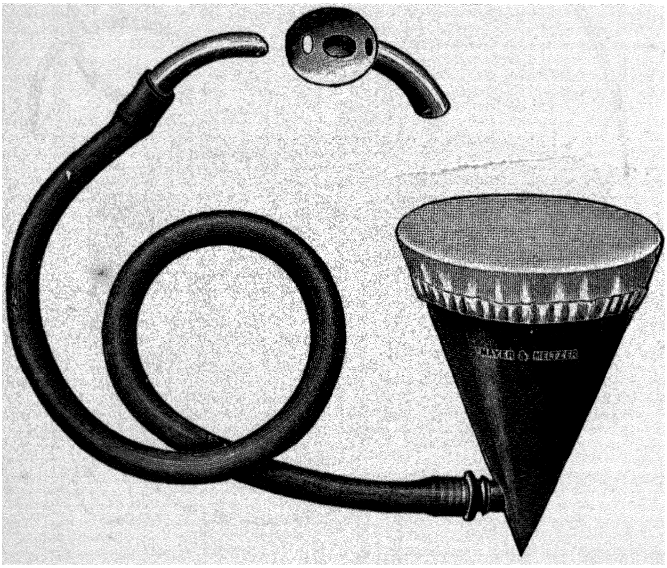


FIG. 291.—Laryngotomy tubes and rubber tubing and funnel for use after preliminary laryngotomy, when operations are being performed in the region of the mouth (BOYLE). The anæsthetist by the use of this arrangement can be located some distance from the head, and hence does not interfere with the operator or his assistant.

An attempt should be made in all cases to remove the cervical lymph glands which receive the lymph vessels from the portion of the tongue which is involved in the disease, and the fascial tissues surrounding them. The submaxillary salivary gland should also be removed, since if it is left behind lymph glands usually escape notice. When the lingual artery is ligatured through a submaxillary incision, in order to control possible hæmorrhage the lymph glands should be removed at the same time. Usually, however, it will be found to be better to remove the tongue, and ten days later to excise the lymph glands and tissues in the neck. Fig. 292 shows the position of the groups of lymph glands which receive lymph vessels from the tongue. Great care is requisite in removing these glands, as they lie in close relation to the submaxillary salivary gland, and one or more are prone to escape observation.

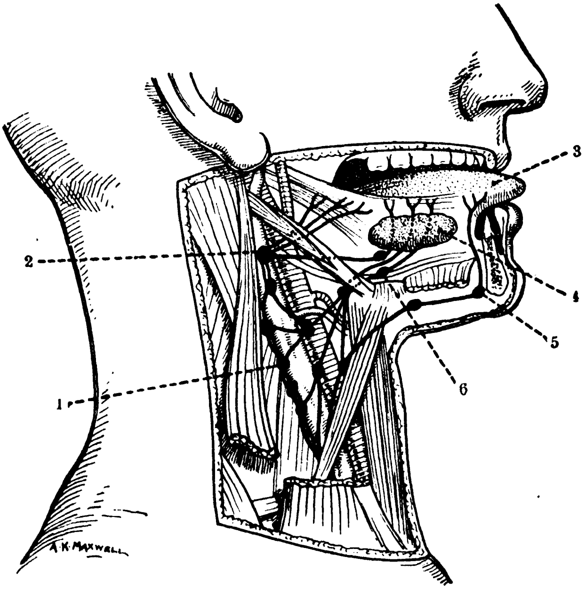


FIG. 292.—Course of lymph vessels and position of lymph glands which receive lymph vessels from the tongue.

1. Lower deep cervical lymph glands.
2. Upper deep cervical lymph glands.
3. Tongue.
4. Submaxillary salivary gland.
5. Submental lymph gland.
6. Submaxillary lymph gland.

(*b*) Sarcoma of the tongue which admits of local removal, and is not associated with the presence of internal secondary growths.

(*c*) Lympho-sarcoma of the tongue.

(*d*) Nævus of the tongue.

(*e*) Lymphangioma of the tongue.

Preliminary preparations.—Before excising either a portion of or the entire tongue, the buccal cavity and pharynx should be made as aseptic as possible. Carious teeth should be extracted, all tartar and incrustations removed by scaling several days before the operation, whilst the use of a toothbrush and an antiseptic mouth-wash should be ordered.

Excision of a portion of the tongue.—Excision of a portion of the tongue may comprise removal of one lateral half, removal of a wedge-shaped portion, and removal of a localised piece from a lateral half.

Excision of half the tongue.—The performance of this operation is indicated in those cases of carcinoma of the tongue in which the disease is absolutely limited to one lateral half, and has not extended to the fibrous tissue which forms the median septum. The operation may be carried out either through the oral aperture, through a submaxillary incision, or after section of the cheek and division or removal of a portion of the lower jaw, as in the class of cases mentioned later in connection with removal of the entire organ. Excision of half the tongue through the oral aperture is indicated when the disease is limited to the diseased half of the tongue, and has not extended to the floor of the mouth and the adjacent tissues, so as to cause extensive infiltration. When the disease mainly involves the lower aspect and outer margin of the tongue, and has extended thence to the adjacent portions of the floor of the mouth and the lower jaw, it is better to split the cheek and remove the portion of lower jaw which is involved, at the same time as and along with the tongue itself. When the jaw is uninvolved, and the floor of the mouth and the underlying tissues are the chief seat of infiltration, median division of the lower jaw should be the variety of operation selected ; whilst, if the lateral and dorsal portions of the tongue are those mainly involved, the diseased half should be excised through the mouth, and the submaxillary and cervical lymph glands, the submaxillary gland, and surrounding and adjacent fascial tissues on the affected side removed at a subsequent operation, about ten days or a fortnight later.

Excision of one-half of the tongue through the mouth.—The lingual artery of the affected side may be tied in the usual manner, and the submaxillary and cervical lymph glands and the submaxillary salivary gland, together with the surrounding and adjacent fascial tissues, removed in those cases in which the mouth and diseased portion of the tongue are in a comparatively clean condition. When the malignant growth is in a foul septic condition, the cervical portion of the operation should be deferred until a later period, for the reasons mentioned on page 427, when discussing removal of the entire tongue.

Special instruments.—Gag, long-handled artery and pressure forceps, long scissors with blades curved on the flat, sharp-pointed needle on a handle, and tongue forceps.

Position.—The patient is placed in the dorsal position with a pillow underneath the neck. The operator stands on the affected side, and his assistant opposite to him.

Operation.—The gag is inserted between the jaws, the blades separated, and the tongue drawn forwards. Two stout silkworm-gut ligatures are then introduced, one into each half of the tongue, 1 inch or thereabouts behind the tip, and each tied in the form of a loop about 6 inches long. One of these is given to the assistant, and, the tongue being drawn forward, the latter is manipulated by this means throughout the operation.

An incision is made with a scalpel through the mucous membrane on the lower and upper surfaces of the tongue in the middle line; and, while traction is exerted laterally by means of the ligatures, the median septum is defined at the tip by a few snips with the scissors. When the median septum has been defined, the two halves of the tongue are torn forcibly apart by the surgeon pulling on the ligatures, and cutting with scissors, and separated as far back as is requisite.

Both halves are then held over towards the unaffected side, and the diseased half cut through transversely at its base from without and below, upwards and inwards, with the scissors. The lingual artery which lies near the lower aspect must be picked up with pressure forceps when it becomes visible, if it has not already been tied during an operation in the neck. Any other bleeding points are also picked up, and the ligatures applied to them. The affected half of the tongue is thus removed.

When all hæmorrhage has been arrested, the cut margins of the mucous membrane in the anterior part are joined by a few points of catgut suture, the stump of the tongue is allowed to fall back into the mouth, and the silkworn gut ligature which has been passed through the unaffected half may be fixed to the cheek with a piece of strapping, if it is considered advisable. This ligature enables the tongue to be readily drawn forwards, if hæmorrhage occur owing to slipping of the ligatures.

After-treatment.—The area of operation should be regularly washed out at short intervals with an antiseptic lotion, and care should be taken, especially when the patient is asleep, to guard against the possibility of secretions from the floor of the mouth being drawn into the bronchi and lungs, which may be the starting-point in the development of "*inhalation pneumonia.*" This can best be avoided by seeing that the patient lies on the affected side with the head turned outwards, and frequently sponging or washing out the mouth.

Operations for removal of one-half of the tongue, either after splitting the cheek and resection of a portion of the lower jaw, or through an incision in the submaxillary region in the neck, are similar to those which are described in connection with removal of the entire organ, with the exception that the tongue is split in the line of the median septum, and the affected half only removed.

Removal of a " wedge-shaped " portion of the tongue.—This operation is necessary in many cases of macroglossia which are not amenable to other means of treatment, and localised innocent new growths, such as papillomata, lymphangiomata, and nævi. It is also indicated in certain early cases of carcinoma of the tongue in which the disease is limited to the region of the tip or lateral margin.

Operation.—The protuberant portion of the tongue is drawn forwards as far as possible, and a wedge or V-shaped incision made in its substance, the base of the wedge including the protuberant portion. The incision is deepened, the muscular tissues being cut through, until the portion of the tongue is removed.

All bleeding vessels are picked up with pressure forceps and ligatured. The incised surfaces are brought into apposition and fixed by the insertion of a number of interrupted sutures. It is advisable to fix the deeper parts together with a few buried sutures of catgut. When the wedge-shaped incision is being made, care must be taken not to leave the lateral portion too thin, otherwise the tongue, when recovery has taken place, will be too pointed.

The operation of removal of the tongue through the oral aperture by means of scissors is often referred to as Whitehead's operation.

Special instruments.—Strong straight blunt-pointed scissors, gag, large needle, sponge-holders.

Position.—The patient is placed in the dorsal posture near one edge of the table, with the head somewhat raised and turned towards the operator. The surgeon stands on the side of the most affected part of the tongue, one assistant stands at the head of the patient, and a second opposite the surgeon.

Operation.—The gag is introduced on the least affected side, and held firmly open by the assistant at the head. A strong ligature is passed through the anterior portion of the tongue, at the junction of the anterior with the middle third. This is left long, and serves as a retractor to pull the tongue forwards. The tongue is drawn forwards and upwards towards the roof of the mouth, whilst the mucous membrane of the floor of the mouth and the anterior pillars of the fauces are divided. This will enable the surgeon to pull the greater part of the tongue out of the mouth, and hence give a better view of the parts which are being operated upon.

The soft parts of the tongue are divided, 1 inch if possible beyond the limits of the growth, by a series of short snips with the scissors from without inwards to the middle line. One or two small arteries will be cut, and when they spurt they are picked up with pressure forceps and ligatured. The lingual arteries, when they have not been ligatured in the neck, are looked for in the anterior part of the incision, on each side of the middle line, and nearer the inferior surface of the organ than the dorsum. When they are seen they are seized with pressure forceps, and divided on the distal side. Next, the remainder of the tongue is boldly cut through with the scissors, and the entire organ removed. Care must be taken to carry the incision well beyond the limits of the disease. The lingual arteries are ligatured, and then the cut surface of the base of the tongue is sponged, and any other bleeding points sought for, and tied. The base of the tongue may be hooked forwards by passing the index-finger into the upper part of the pharynx, and exerting forward traction. This proceeding is of considerable value in the temporary arrest of hæmorrhage from the lingual arteries, if they have been divided before being seized with pressure forceps. The vessels are compressed against the posterior aspect of the lower jaw.

Before the operation is finished, a loop of strong silk should be passed through the stump of the tongue. This is brought out through the mouth, and fixed to the cheek with a piece of strapping. It will serve to pull the stump of the tongue forwards, and help in the control of hæmorrhage should it occur.

When all the hæmorrhage from the base of the tongue and the floor of the mouth has been arrested, the incised surfaces are sponged dry, and if possible portions of the divided mucous membrane of the floor of the mouth in front and laterally, and the base of the tongue behind, joined together by the insertion of a number of sutures of chromicised catgut. The unsutured portion is packed with a piece of gauze, and the operation is completed.

Excision of the cervical lymph glands, submaxillary salivary gland, and fascial structures of the neck in carcinoma of the tongue and floor of the mouth.

Position.—The patient is placed in the dorsal posture, the head being turned towards the opposite side, and the shoulders slightly raised in order to throw the head somewhat backwards. The surgeon stands on the side of the patient which is to be operated upon, and his assistant opposite to him.

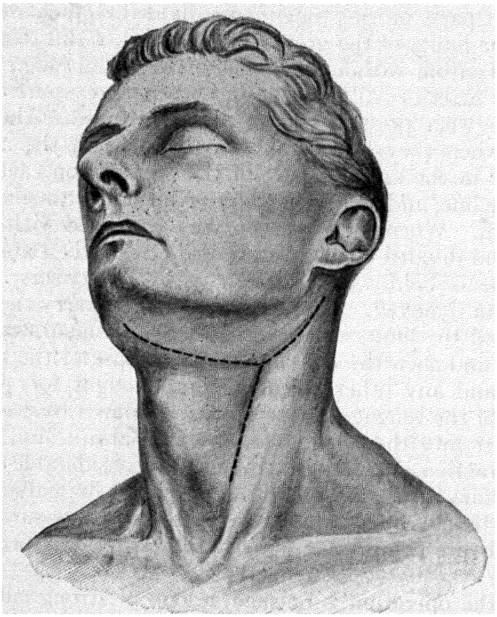
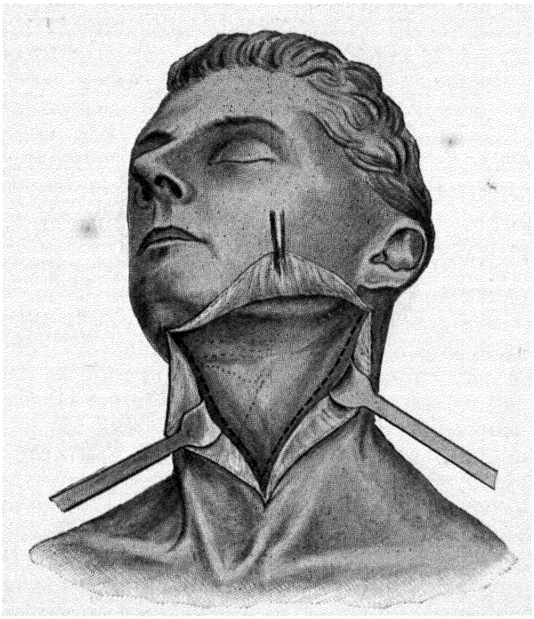


FIG. 293.—Removal of cervical lymph glands. Skin incisions.

Operation.—A semilunar incision, placed as far as possible in the natural fold or crease of the neck, is made, extending from the anterior border of the sterno-mastoid a little below the level of the apex of the mastoid process downwards and forwards to the middle line of the neck, about half-way between the mental process and the body of the hyoid bone. From the convexity of this incision and a little in front of the anterior margin of the sterno-mastoid, a second incision is made downwards to the level of the cricoid cartilage, or even lower according to the extent of the glandular infection. Some surgeons recommend prolonging the lower limb of the incision as far as the upper border of the sterno-clavicular articulation, but in my opinion this in most cases is not necessary. When these incisions have been made, three flaps of skin and subcutaneous tissues are dissected free—one upwards, one outwards, and one inwards. The deep fascia is next divided along the internal and external margins of the triangular-shaped space thus exposed, and, commencing at the angle below, a triangular-shaped flap of fascial tissues and attached lymph glands and vessels is dissected upwards until the horizontal ramus of the lower jaw is reached. Careful and delicate dissection is necessary in order to separate all the cervical lymph glands along with the fascial tissues, and to avoid injury to the contents of the carotid sheath. In the upper part of the dissection the external maxillary (facial) artery must be recognised before it enters the groove in the submaxillary salivary gland and ligatured. The salivary gland is



Superficial dissection.

isolated from its deep connections, its duct ligatured, and then the entire separated mass of cervical lymph glands, submaxillary salivary gland, and fascial tissues removed by cutting through the upper attachments in the region of the horizontal ramus of the lower jaw. During this division the external maxillary (facial) artery will again be cut and require ligature, and also a number of facial veins. The entire space is next carefully sponged in order to enable the operator to detect any small bleeding points, all of which are picked up and ligatured with catgut. Finally the margins of the flaps, consisting of skin and subcutaneous tissues, are brought into exact apposition, and fixed by the insertion of interrupted sutures of salmon gut. A small rubber drainage tube should be inserted into the deep part of the wound in the submaxillary region, otherwise accumulation of blood and serum may occur and later become a source of trouble.

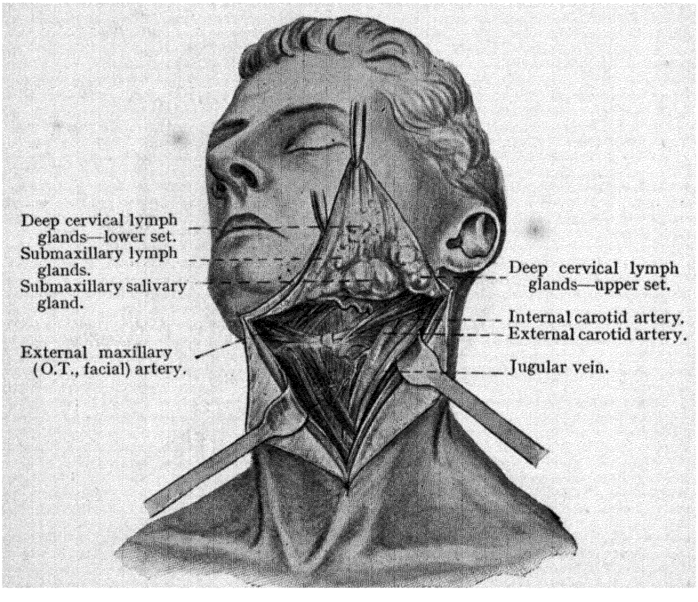

Deep cervical lymph glands—lower set.
Submaxillary lymph glands.
Submaxillary salivary gland.
External maxillary (O.T., facial) artery.
Deep cervical lymph glands—upper set.
Internal carotid artery.
External carotid artery.
Jugular vein.

FIG. 295.—Removal of cervical lymph glands. Deep dissection.

Excision of the entire tongue.—Through the mouth.— Excision of the entire tongue through the mouth is the more usual operation practised for extensive carcinoma, since this method permits complete removal of the diseased organ, and does not leave a visible scar. It must be borne in mind, however, when deciding upon the adoption of this method, that in all cases where malignant disease (carcinoma) has been present for some time, the muscles of the tongue are frequently the seat of carcinomatous infiltration, and in order completely to remove all affected tissues, certain muscles must be removed down to their attachments to the hyoid bone and the styloid process. This free removal of the muscles gives rise to considerable limitation in movements of the stump of the tongue and floor of the mouth. The lymphatic vessels in some instances themselves appear to have been the seat of the carcinoma cells or elements, and secondary growths have commenced in them. Usually, however, the carcinomatous elements are carried direct to the lymph glands in the neck, and are not arrested in the course of the lymphatic vessels.

In all cases the cervical operation must also be carried out on one or both sides according to the method already described. Whenever a carcinomatous growth of the tongue extends to the middle line of the tongue or beyond, the lymph structures on both sides will probably become infected with the disease. Operation on both sides will then be necessary, but one side at a time should only be operated upon, the side of the affected portion of the tongue being selected first. When the carcinomatous growth of the tongue is in a septic and foul condition, it is better not to ligature the lingual artery in the neck at the time of removal of the tongue, but at a later period to remove the submaxillary and cervical lymph glands and fascial tissues at a second operation. In septic cases of this kind, suppuration in the cervical wound is liable to happen, which may cause serious consequences, such as cellulitis in the fascial planes of the neck, and secondary hæmorrhage from the lingual artery.

Excision of tongue with median incision of the lower lip and division of symphysis of lower jaw.

Special instruments.—Gag, saw, bone forceps, tooth forceps, bone drill, silver wire, and thermo-cautery (if it is to be used).

Position.—The patient is placed in the dorsal position with the shoulders and head raised. Usually it is best to administer the anæsthetic by the intra-tracheal method. If it is decided to perform a preliminary laryngotomy, this should be done before raising the head and shoulders. The operator stands on the right side of the patient, and his assistant directly opposite.

Operation.—(*a*) *Parietal incision, drilling of lower jaw, division of symphysis menti, and removal of teeth if necessary.*—A vertical incision is made through the soft tissues of the lower lip and the submental region, which commences above at the middle line of the lower lip, and extends downwards to immediately above the upper border of the body of the hyoid bone (Fig. 297). The soft tissues of the lip, including the internal mucous membrane and the periosteum on the external aspect of the lower jaw, are cut through. Next, whilst the jaw is supported by the assistant, the body of the jaw ¼-inch on each side of the middle line is drilled, in order to make apertures for the insertion of a wire suture later. If necessary, one central incisor tooth is extracted, and the bone at the symphysis then sawn through, attention being paid to the structures on the deep aspect so as not to lacerate them more than is requisite. This division having been effected, the two halves are pulled apart, the genio-hyoid and genio-hyoglossi muscles separated, and the lower aspect of the tongue and floor of the mouth exposed to view. A loop of strong silk is passed through the anterior portion of the tongue, and with this the tongue is pulled forwards and towards the sound or least affected side. Strong scissors are now taken, and the mucous membrane of the floor of the mouth on each side divided from before backwards, the line of section being carried as widely as possible of the diseased area. This division of the mucous membrane will expose the lingual vein as it lies upon the hyoglossus muscle, and the lingual nerve on the inferior and lateral margin of the tongue

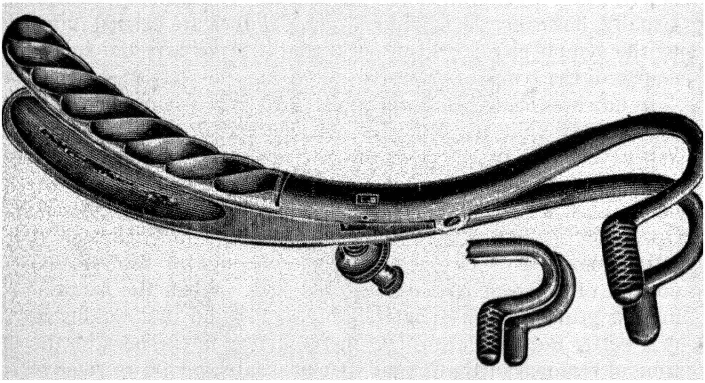


FIG. 296.—Excision of tongue. Gag for keeping the jaws separated.

close underneath the mucous membrane. The hypoglossal nerve lies deeper upon the external surface of the hyoglossus, and sends branches forwards to the genio-hyoglossus. These branches should be preserved, if they can be avoided with safety, in order to leave the floor of the mouth in as satisfactory a condition as possible. If, however, the margins of the carcinomatous growth render this impossible, the surgeon should not hesitate to divide them, otherwise local recurrence will be rendered probable. The lingual artery will be seen lying between the hyoglossus and genio-hyoglossus, as it passes upwards, and should be picked up and ligatured. The hyoglossus is next cut through and the tongue pulled further forwards, and the mucous membrane on its dorsum divided with

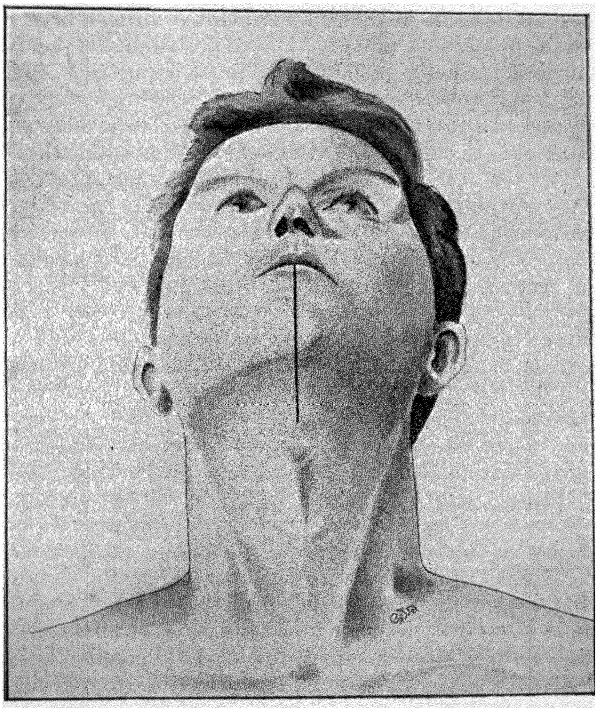


FIG. 297.—Excision of tongue with median division of lower lip. Position of incision.

the scissors. It may be necessary, in order to carry the incisions well beyond the margins of the diseased area, to encroach upon the adjacent parts of the soft palate, the tonsil, and the lateral wall of the pharynx. Similar incisions are made on the other side, and then the base of the tongue is cut through with the scissors and the organ removed. Some surgeons prefer to effect the section of the substance of the tongue with the thermocautery, on account of the small amount of hæmorrhage which follows the proceeding, and the lessened probability of recurrence. Hæmorrhage, however, is not of any great importance, since the tongue, being well pulled forwards, each bleeding artery can be readily picked up and ligatured, and as regards recurrence it is not my experience that it is more frequent after removal with scissors than after removal with the knife of the thermocautery.

(*b*) *Approximation and suture of a portion of the margins of the incisions in the stump of the tongue and mucous membrane of the floor of the mouth, and union of the jaw.*—All hæmorrhage having been arrested, the stump of the tongue is pulled forwards, and the margins of the divided mucous membrane on the dorsal and lateral aspects fixed if possible to the margins of the wound in the floor of the mouth by sutures. This method of fixation helps in the prevention of the tongue falling back, hastens union, and enables the patient to swallow more easily. The sawn surfaces of the lower jaw are brought together, and a silver-wire suture introduced through the holes already drilled, and tied.

(*c*) *Drainage and packing of wound and closure of incision in lip and neck.*—A large rubber drainage tube is passed into the lower part of the wound from the neck, and the part around packed with strips of gauze. The margins of the divided lip and the wound in the neck are brought together and united by the insertion of a series of salmon-gut sutures, with the exception of the lowest portion, which is left open for the exit of the lower end of the rubber drainage tube. Dressings are then applied.

After-treatment.—The main points to be borne in mind in the after-treatment are that free drainage should be established, discharges should not be allowed to collect in the mouth, and frequent irrigation or washing out of the mouth with an antiseptic solution should be assiduously practised. The patient also should be allowed to sit up as much as possible.

Excision of the tongue after splitting the cheek, and division or resection of a portion of the lower jaw.—This operation is especially applicable in those cases of carcinoma of the tongue which extend backwards and infiltrate the region of the fauces, the floor of the outer portion of the buccal cavity, and the adjacent part of the lower jaw. This method of operation gives very free exposure of the diseased areas, and enables the surgeon to take away all the infiltrated tissues. Some surgeons object to the operation on account of the deformity which results, and also to an increased mortality owing to the development of septic processes in the neck. As regards the first objection, this has been very much overrated, since, if care be taken carefully to suture the divided portions of the cheek together, little if any visible deformity results. Concerning the increased mortality from septic causes, this has not been my experience, provided each patient is well looked after for the first week, and efficient drainage is provided in the lower portion of the wound so as to avoid any accumulation of septic discharges.

Special instruments.—Gag, saw, bone forceps, tooth forceps.

Position.—The patient is placed in the dorsal position, with a firm sandbag underneath the shoulders, and the head turned towards the sound side. The operator stands on the affected side of the patient, and the assistant opposite to him.

Operation.—Usually it will be found best to have the anæsthetic administered by the intra-tracheal method, but in occasional cases it may be necessary to perform a preliminary laryngotomy, and afterwards to plug the pharynx with a marine sponge.

The operation can be most conveniently divided into the following five stages :—

(*a*) *Skin incision and splitting the cheek.*—The assistant grasps the cheek on the affected side so as to control the circulation, and then the surgeon makes an incision which commences at the angle of the mouth (Fig. 298), extends horizontally backwards to the anterior margin of the masseter, downwards parallel to the anterior margin of this muscle as far as the inferior margin of the horizontal ramus of the lower jaw, and then onwards to the anterior margin of the sterno-mastoid muscle in the submaxillary region, whence it is curved inwards, forwards, and upwards for about 1 inch in the direction of the symphysis menti. This incision is made to divide all the tissues of the cheek, and to expose the lower jaw and the anterior margin of the sterno-mastoid muscle. In the outer part of the incision over the ramus of the jaw, or on the anterior margin of the masseter, the external maxillary (facial) artery will be divided and will require ligature. Other vessels requiring ligature are the coronary arteries in the region of the angle of the mouth. The flap thus formed by the cheek and tissues of the neck is next dissected downwards and forwards, so as to expose fully the horizontal ramus of the lower jaw and the structures in the submaxillary triangle.

(*b*) *Division or resection of a portion of the lower jaw.*—When it is not necessary to remove a portion of the lower jaw, on account of its freedom from disease, it is sawn through immediately behind the last molar tooth. The anterior segment is then drawn forwards and towards the opposite side, whilst the other part is pulled forcibly outwards and backwards. By these means the lateral aspect of the tongue, the floor of the mouth, and the region of the fauces are laid bare. When, however, a portion of the jaw is involved in the disease, the limits of the infiltrated bone are exactly defined, the tooth at each extremity of the affected portion removed, and then with a small saw the ramus of the jaw is sawn through in front of and behind the region of the infiltrated portion. Great care must be taken to make the section of the bone wide of the disease. When the bone has been sawn through, the separated portion is removed and the two segments pulled aside, so as to give a full exposure of the interior of the buccal cavity and the extent of the disease.

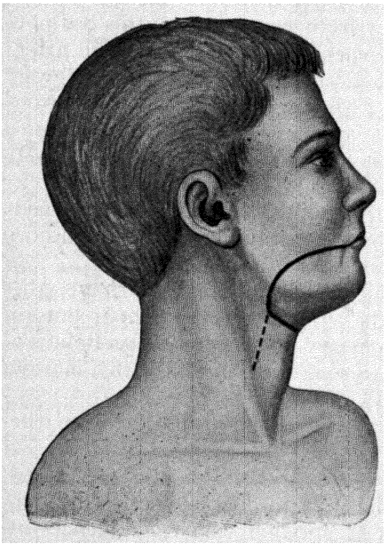


FIG. 298.—Position of incision for removal of tongue, after splitting cheek and dividing lower jaw.

(*c*) *Removal of tongue.*—This having been done, the mucous membrane of the floor of the mouth is cut through 1 inch beyond the margins of the diseased area, the pillars of the fauces divided, if necessary, and the tongue cut through well behind the infiltrated or ulcerated portions. When only one-half of the tongue is involved, the mucous membrane should be divided along the middle line on the dorsal and ventral aspects, and the organ split backwards into two halves. These cutting operations can be most easily done with strong curved scissors. In cutting through the substance of the tongue, especial care should be taken, when the ventral aspect is being reached, to discover the position of the lingual arteries, and, when seen, these should be seized with pressure forceps before section. The sublingual glands can generally be removed at the same time as the tongue.

(*d*) *Removal of the submaxillary salivary and lymph glands.* —When the tongue has been removed, the region of the submaxillary triangle should be investigated, and the submaxillary salivary and lymph glands removed. It is desirable also, in cases of extensive disease, to investigate the vertical chain of lymph glands along the anterior border and deep aspect of the sterno-mastoid, and if any of these are enlarged they ought to be dissected free from their surroundings and taken away.

(*e*) *Closure of external wound.*—If possible, the margins of the mucous membrane on the dorsum of the stump of the tongue should be approximated to the cut margins of the mucous membrane of the floor of the mouth by a few sutures. This tends to prevent falling back of the stump of the tongue over the upper aperture of the larynx, and facilitates healing. In those cases in which the lower jaw has been divided, and no portion taken away, the two fragments are brought into apposition, drilled with some form of bone perforator, and then fixed in close connection by the insertion of a suture of silver wire. When, however, a segment of bone has been removed, after all hæmorrhage has been arrested, the cavity of the wound is packed with strips of gauze. Finally, the margins of the wound are fixed close together by the insertion of a series of interrupted silkworm-gut sutures. Especial care should be taken to secure exact coaptation in the region of the angle of the mouth. The lowest and most dependent portion of the wound should be left unsutured, and through it either a strip of gauze or a drainage tube brought out.

When the operation has been completed, the laryngotomy tube is removed, and the external incision covered by a dressing. Before removing the tube, care must be taken to remove the sponge-plug from the upper portion of the pharynx, and to sponge all the air-passage free of blood-clot.

After-treatment.—The gauze packing should be left in for about twenty-four hours, and then removed. The entire wound should be frequently syringed out with an antiseptic solution, and great care taken to ensure free exit and early removal of all discharges which may collect.

Removal of submaxillary salivary gland.

Indications.—The submaxillary salivary gland requires removal for—

(i) Different forms of tumours.
(ii) Calculi, embedded in its interior.
(iii) Stricture of its duct when it is not amenable to dilatation.
(iv) External salivary fistula due to stricture of the duct.

Position.—The patient lies in the dorsal position near the end of the table, with the shoulders raised, the chin turned upwards and slightly to the opposite side, and held in position by an assistant. The surgeon stands on the side which is to be operated upon, the chief assistant on the opposite side, and the second assistant near the operator.

Operation.—A curved incision is made which commences half an inch lateral to and a short distance below the symphysis menti and extends downwards to the apex of the great cornu of the hyoid bone and then upwards to a point a little behind the angle of the mandible (Fig. 299). This incision divides the skin, the superficial fascia with the platysma and the deep fascia for its entire length. Any small superficial veins are seized with pressure forceps before division, and if any branch of the facial nerve is seen, it should be retracted aside, if possible, and not divided. The flap of superficial tissues which has been marked out is dissected upwards and then retracted towards the face. The superficial portion of the submaxillary salivary gland will be exposed then. By dissection, the fibrous tissue connections and surroundings of the gland are cut through. The superficial portion of the salivary gland is next lifted up from the surface

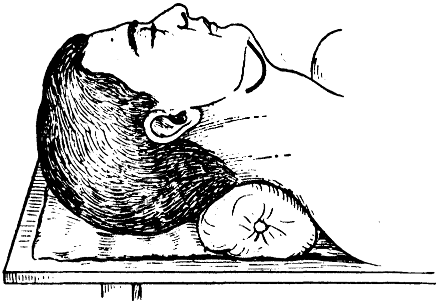


FIG. 299.—Removal of submaxillary salivary gland. Position of skin incision,

of the mylohyoid and hyoglossus muscles and further retracted upwards. During this procedure, the facial artery will be seen and should be seized with two pairs of pressure forceps, cut and ligatured. In the deeper part of the wound will be seen lying on the lower portion of the hyoglossus, the lingual branch of the fifth nerve and hyoglossal nerve. Care should be taken not to interfere with these structures. After division of the facial artery in the deeper part of the wound, the submaxillary salivary gland is retracted somewhat backwards and the facial artery will be seen again as it is crossing the lower margin of the mandible. This vessel is again seized with two pairs of forceps, divided, and the distal end ligatured. The salivary gland can now be entirely separated from its fibrous tissue connections on the inner aspect of the maxilla. Traction is then exerted upon it and the deep portion drawn out from behind the mylohyoid muscle. The duct of the gland will then be fully exposed as it passes forwards towards the mucous membrane of the floor of the mouth. This duct is ligatured a short distance from its point of emergence from the gland, and divided. The mucous membrane of the stump should be cauterised either with the actual cautery or liquefied carbolic acid. The field of operation is next sponged dry. If any bleeding points are observed, they are picked up and ligatured. The margins of the wound are then sutured in exact apposition and dressings firmly applied. It is not usually necessary in cases of removal of the submaxillary salivary gland to put in temporary drainage. In cases of suppuration, however, it may be advisable to put in a temporary drain in the dependent portion of the wound, which can be removed at the expiration of 24 or 36 hours.

CHAPTER XVII

OPERATIONS UPON THE THYROID GLAND

EXTIRPATION OF ONE LOBE.
ENUCLEATION OF ENCAPSULED TUMOURS (CYSTS AND ADENOMATA).

Extirpation of one lobe.—Unilateral extirpation of the thyroid gland is usually carried out through an incision along the anterior border of the sterno-mastoid muscle of the affected side, or through a transverse or curved incision.

Indications.—(*a*) Bilateral bronchoceles (parenchymatous goitres) which do not yield to medicinal treatment, and which are growing and causing serious dyspnœa owing to pressure upon the trachea.

(*b*) Multiple cysts or adenomata of one-half of the gland.

(*c*) Some cases of exophthalmic goitre.

(*d*) Some forms of malignant disease of the thyroid gland, when the surrounding structures are not infiltrated. When the disease has spread to the adjacent tissues it is not advisable to attempt removal, owing to the important structures which are involved.

On account of the difficulties which may occur in connection with respiration, it is often safer to perform an operation upon the thyroid gland under local anæsthesia. Recently I have found that anæsthetisation, with nitrous oxide gas and oxygen administered by the intra-tracheal method, is of great value in operations upon the thyroid gland.

Position.—The patient lies in the dorsal position, with the head turned slightly towards the sound side, the neck being supported by a hard pillow or sandbag, or with the headpiece of the operation table arranged as in Fig. 300. The operator stands on the affected side of the neck, and his assistant directly opposite to him.

Operation.—Removal of one-half of the thyroid gland may be divided into the following stages :—

(*a*) *External incision.*—An incision from 3 to 8 or 10 inches in length, according to the size of the lobe to be removed, is made over the prominent part of the swelling, and either in a line from the sternal extremity of the clavicle to the mastoid process, or a semilunar incision placed obliquely. Fig. 302 shows the three forms of incision which may be used, the semilunar one placed as transversely as the necessities of the case will allow, being the one recommended, on account of the less visible scar which results (Fig. 302, *c*). This incision divides the skin, superficial fascia, platysma, and the anterior jugular vein or one of its tributaries. The external jugular vein may be exposed at the upper end of the incision, and should be drawn aside. These veins lie underneath the platysma, but in the superficial fascia.

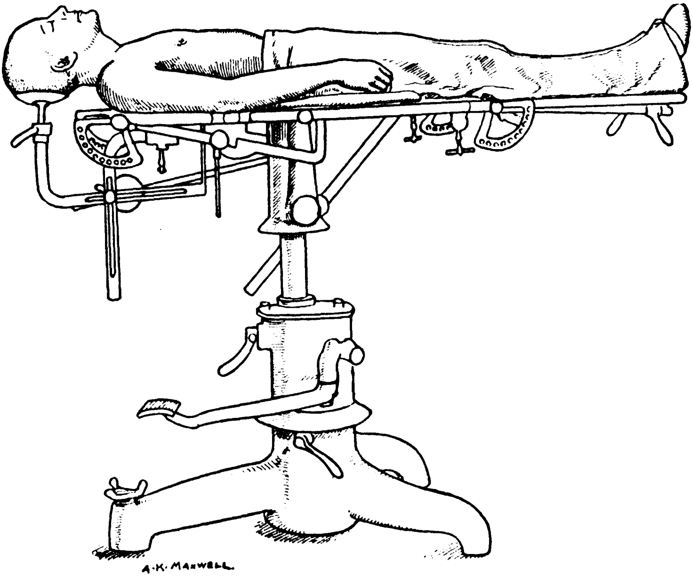


FIG. 300.—Position of patient for operations on the thyroid gland.

(*b*) *Division or retraction of infra-hyoid muscles, and exposure of the thyroid gland.*—The deep fascia which has been laid bare in the first incision is divided for the entire length of the wound, and the anterior border of the sterno-mastoid muscle exposed. This is pulled outwards with retractors. The infra-hyoid muscles (sterno-hyoid, sterno-thyroid, and omo-hyoid) are now seen lying spread out upon the gland. They must be carefully retracted outwards, and if necessary their attachments divided transversely just below the hyoid bone. In the case of large goitres, they frequently lie in deep grooves in the gland. The enlarged lobe of the thyroid will now be apparent.

The sheath or capsule of the thyroid gland will now be exposed, and running in this sheath numerous veins will be visible. Incision of this sheath must be carefully avoided, or serious and perhaps uncontrollable hæmorrhage may occur.

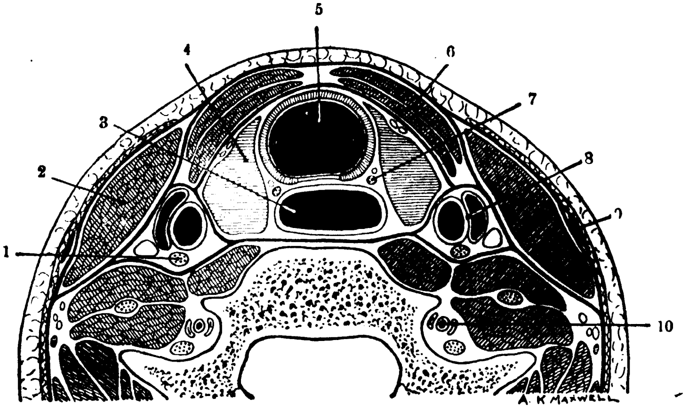


Fig. 301.—Transverse section through the anterior part of the neck at the upper margin of the isthmus of the thyroid gland.—Cunningham.

1. Vagus nerve.
2. Sterno-mastoid.
3. Œsophagus.
4. Thyroid gland.
5. Trachea.
6. Sterno-hyoid and sterno-thyroid muscles.
7. Recurrent laryngeal nerve.
8. Common carotid artery.
9. External jugular vein.
10. Vertebral vessels.

(*c*) *Isolation of the lobe, ligature of the thyroid vessels, and division of the isthmus.*—The superior thyroid artery and vein, and the middle and inferior thyroid veins, are now carefully isolated, tied with double ligatures, and divided. The lateral lobe of the gland is now lifted forwards and inwards. Special attention must at this point be paid to the breathing, which is apt to become seriously embarrassed if there is much pressure upon the trachea.

Any prolongation of the enlarged gland behind the pharynx, trachea, or œsophagus is dealt with during this stage.

The swelling must now be separated from its connections with the lateral portion of the larynx, the operator dissecting from above downwards. The isthmus is now met with, attaching the gland to the anterior aspect of the trachea, and the lateral lobe of the opposite side. With blunt instruments the isthmus is separated from the trachea, and then clamped or tied. The isthmus is then divided on the proximal (or tumour) side of the ligatures, and the separation of the tumour continued. When the isthmus is very large it is better to cut it across and tie the blood vessels separately. If necessary, pressure forceps are placed on the blood vessels of the tumour. The dissection is prolonged downwards until the inferior limits of the tumour are reached; in this stage it is occasionally necessary, when the lateral lobe of the thyroid extends to the upper aperture of the thorax, to expose the dome of the pleura, the subclavian artery, and the large veins.

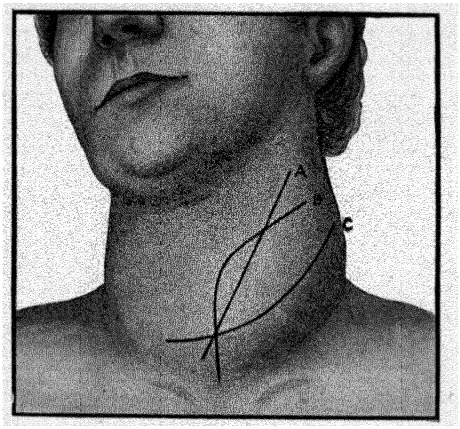


FIG. 302.—Excision of the thyroid gland.—BERRY.

a. Position of oblique incision for removal of left lobe.
b. Position of semilunar incision with convexity upwards.
c. Position of semilunar incision for removal of left lobe.

When the thyroid gland has been separated from all these connections, the inferior thyroid artery and accompanying veins will be usually readily found entering the posterior and inner aspect of the gland, on a level with the upper rings of the trachea. Great care should be taken to avoid injuring the recurrent laryngeal nerve, which, by the side of the trachea, lies in very close relation to the artery. The main artery may be tied outside the nerves, or the separate branches may be tied on the medial side of the nerve and just before they enter the gland.

(*d*) *Removal of the lobe, and closure of external wound.*—The inferior thyroid vessels having been ligatured, they are cut, the enlarged lobe is lifted upwards, and any fascial connections which still remain undetached are divided, and the tumour removed. The bottom of the wound is sponged dry, and all bleeding points picked up with artery forceps and carefully ligatured. Care must be taken in so doing that too much tissue is not taken up with the blood vessels, otherwise branches of the sympathetic cord, or the recurrent laryngeal nerve itself, may be surrounded by the ligature.

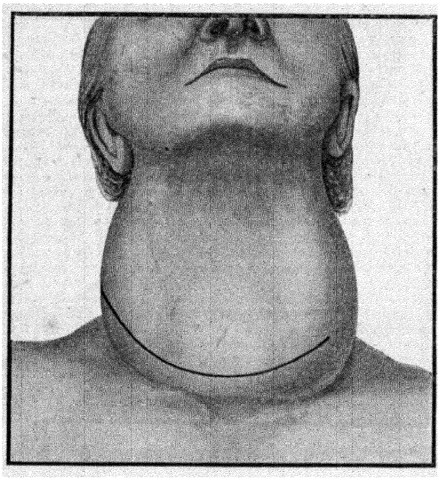


FIG. 303.—Transverse curved incision for removal of large tumour of thyroid gland.—BERRY.

All bleeding having been most carefully arrested, the divided infra-hyoid muscles are reunited by buried sutures, and the external incision is then closed by the insertion of a row of salmon-gut sutures.

The inferior extremity of the wound when there has been much oozing should be left open, and a drainage tube of soft rubber or a strip of gauze introduced. This is often necessary on account of the large size and great depth of the wound, and of the difficulty of applying sufficient pressure without causing interference with respiration.

Dressings are applied, and held in position by bandages which are made to include also the head and shoulders.

The chief dangers in the removal of thyroid tumours are the occurrence of serious hæmorrhage, and the division or ligature of nerves. These, however, can be avoided by attention to the precautions given above.

If, during the course of the operation, the breathing becomes very much embarrassed, owing to pressure of the tumour on the trachea, it may occasionally be necessary to perform tracheotomy. This should, however, be avoided, if possible, since, when tracheotomy has been performed, the wound in the neck, in nearly all instances, becomes infected with septic micro-organisms. This usually results in suppuration, which is very prone to extend to the mediastinum and cause a fatal termination.

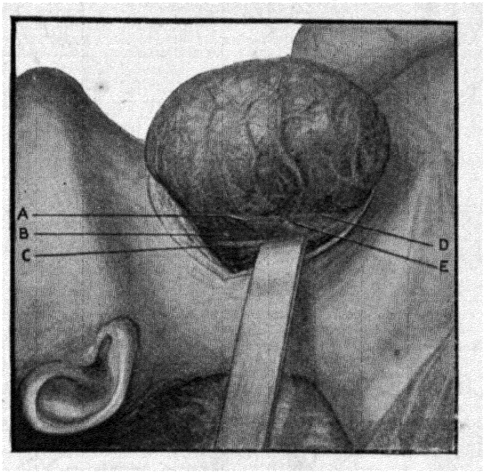


FIG. 304.—Removal of the right half of an enlarged thyroid gland. The separated right lobe has been lifted up and turned towards the middle line.—BERRY.

A. Œsophagus.
B. Prevertebral muscles.
C. Carotid sheath.
D. Recurrent laryngeal nerve.
E. Inferior thyroid artery and veins.

Removal of the entire thyroid gland is rarely, if ever, advisable, on account of the complications which occur after such an operation. The mental condition of the patient is seriously affected, and the operation may be followed by a kind of myxœdema.

Enucleation of encapsuled tumours (cysts and adenomata).—When cysts and adenomatous tumours of the thyroid gland only involve a part of the affected lobe, it is preferable to attempt a local removal in place of extirpation of one-half of the gland.

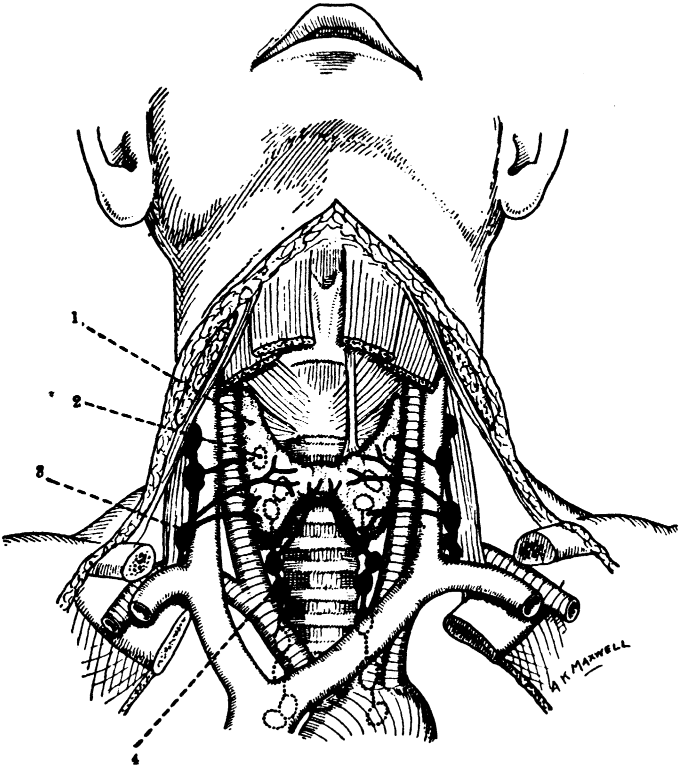


FIG. 305.—Course and arrangement of lymph vessels and position of lymph glands which receive lymph vessels from the thyroid gland.

1. Thyroid gland.
2. Retro-thyroid lymph glands.
3. Supra-clavicular lymph glands.
4. Supra-sternal lymph glands.

Special instruments.—As for removal of a lateral lobe ; a blunt thyroid scoop or enucleator is useful.

Position.—As for preceding operation.

Operation.—An incision is made over the most prominent portion of the swelling. The incision is deepened until the external aspect of the affected portion of the gland is exposed. There is invariably a layer of gland tissue lying in front of the tumour; this may be thick, and resemble normal gland tissue, or it may be thin, and look like fascia. This must be divided, and the surface of the cyst or adenoma laid bare. The surface of a cyst or tumour can generally be recognised by its bluish colour.

The glandular capsule of the cyst or tumour having been divided, the localised swelling is separated from its bed with a director, finger, a thyroid scoop, or other blunt instrument, and removed. In some cases of cystic swelling, removal will be much facilitated by incision of the cyst wall, and evacuation of the contents. During and immediately after the enucleation there is often profuse hæmorrhage, which must be stopped by forceps, by pressure of sponges, and by eversion of the wound, so as to give easy access to the deeper parts of the cavity. The space from which the cyst or adenoma has been removed should be obliterated by the insertion of a continuous suture of catgut, which is so introduced as to obliterate the space by bringing the walls and the margins of the incision in the gland into exact apposition. This is preferable to ligature of individual bleeding vessels, since it is more effective and much quicker in execution. The external wound is closed by sutures except at one extremity, where a drainage tube or strip of gauze is brought out.

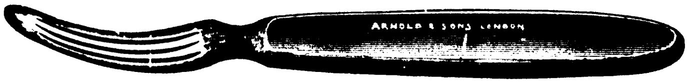


FIG. 306.—Thyroid enucleator.

In some few cystic swellings it will be found impossible to effect a local removal, on account of the vascularity of the walls and the absence of a distinct fibrous tissue capsule. Extirpation of one-half of the thyroid gland must then be effected. In very rare cases of cysts fixed by old inflammation it may be better to be content with mere drainage, carried out after incision of the cyst wall, evacuation of the contents, and stitching of the margins of the incision in the cyst to those of the parietal wound. Cysts so treated, however, are prone to suppurate, a condition which is to be avoided if possible.

Enucleation of very large tumours may be attended with a dangerous amount of hæmorrhage. In these cases it is generally best to perform resection enucleation, in which the size of the wound in the gland is greatly reduced.

CHAPTER XVIII

OPERATIONS UPON THE ŒSOPHAGUS

ŒSOPHAGOTOMY, OR INCISION OF THE ŒSOPHAGUS.
ŒSOPHAGOSTOMY.
ŒSOPHAGECTOMY, OR EXCISION OF A PORTION OF THE ŒSOPHAGUS.
REMOVAL OF A POUCH OF THE ŒSOPHAGUS.

Œsophagotomy.—Œsophagotomy, or the making of an incision into the œsophagus, is usually carried out through an incision placed in the inferior part of the left anterior triangle of the neck.

The œsophagus commences opposite the middle of the cricoid cartilage, at the level of the upper part of the sixth cervical vertebra, or the disc between the fifth and sixth, and terminates immediately below the œsophageal opening in the diaphragm.

The cervical portion of the tube is the part upon which the operation of œsophagotomy is generally performed; but the œsophagus may be exposed as it lies within the thorax, through an incision on the left side of the spinal column, after portions of two or more ribs have been resected.

The cervical operation will be described.

Indications.—(*a*) Impaction of a foreign body, such as a tooth-plate, in the œsophagus.

(*b*) Some forms of fibrous stricture occurring high up in the œsophagus, and which cannot be dilated by means of œsophageal bougies passed through the mouth, or divided by an operation carried out through the tube of an œsophagoscope which has been passed down to the upper level of the stricture.

(*c*) Pedunculated fibrous tumours of the œsophagus, which project internally and cannot be readily removed at an intra-œsophageal operation carried out through the tube of an œsophagoscope.

Special instruments.—Long-bladed forceps and œsophageal bougies.

Position.—The patient lies in the dorsal position, with a sandbag underneath the neck. The head is turned towards the right side. The surgeon stands on the left side of the patient's neck, and his assistant on the right.

Operation.—The operation of œsophagotomy may be carried out in the following stages, namely :—

(*a*) *External incision.*—An incision from 3 to 4 inches in length is made along the anterior border of the left sterno-mastoid muscle, commencing at the sternal extremity of the left clavicle, and extending upwards as far as the upper border of the thyroid cartilage. This incision divides the skin, superficial fascia and platysma, as well as the deep fascia, and exposes the external surface and anterior border of the sterno-mastoid muscle.

(*b*) *Exposure of œsophagus.*—The anterior border of the sterno-mastoid muscle is well defined, and the structure retracted to the outer side, by which means the infra-hyoid group of muscles will be laid bare. The anterior jugular vein will be met with usually at this stage, and should either be drawn aside or ligatured. The layer of deep cervical fascia which lies behind the sterno-mastoid is incised, so as fully to expose the infra-hyoid group of muscles. The intermediate tendon of the omo-hyoid is cut through, and the infra-hyoid group of muscles retracted towards the medial side.

In the floor of the incision the left lateral lobe of the thyroid gland, covered by fascia, is seen internally, and the carotid sheath with its contents externally. The fascia which covers the thyroid gland is divided ; the gland is drawn medially, and the carotid sheath laterally. The deep fascia which is exposed at the bottom of the wound is incised in the line of the original incision, and the above-mentioned structures further retracted. The inferior thyroid artery will now be laid bare in the lower part of the wound. It is surrounded with ligatures in two places, and divided between. In the bottom of the wound the anterior aspect of the longus colli muscle will be seen, and on the medial side the œsophagus, which can be recognised by its red colour.

The recurrent laryngeal nerve of the left side must be carefully avoided ; it lies in the chink between the trachea and the œsophagus. It can be pulled to the medial side with a blunt hook.

(*c*) *Incision of the œsophagus, removal of the foreign body, or dilatation of the stricture.*—When the foreign body is impacted in the exposed portion of the œsophagus an incision should be made through the wall of the tube in a longitudinal direction, and the obstruction removed with long-bladed forceps. If the impacted body is situated at a lower level, but can be readily felt, an œsophageal bougie is passed down the œsophagus, and a cut made on to it in a longitudinal direction. The bougie is then withdrawn, and the margins of this incision are held apart with retractors, and long-bladed forceps passed downwards, and an attempt made to extract the impacted body.

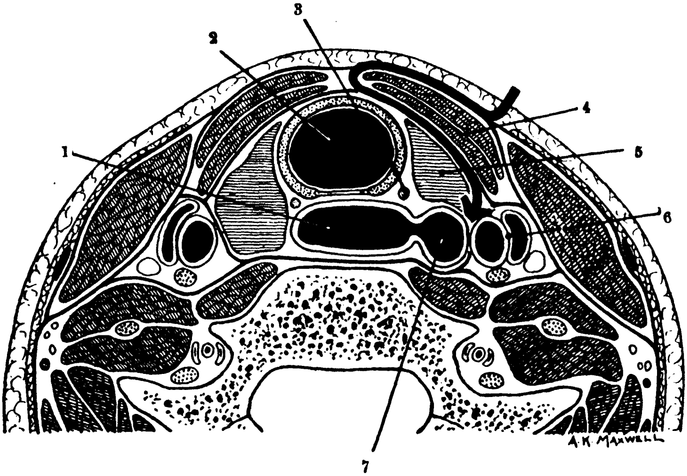


FIG. 307.—Transverse schematic section of the neck at the level of the cervical vertebra, showing the anatomy of the parts concerned in exposure of the œsophagus through a cervical incision. The arrow denotes the route of possible surgical approach.

1. Œsophagus.
2. Trachea.
3. Recurrent laryngeal nerve.
4. Sterno-hyoid and sterno-thyroid muscles.
5. Thyroid gland.
6. Common carotid artery
7. Œsophageal pouch.

In the case of fibrous stricture a bougie is passed downwards until the upper limit of the stricture is reached ; a longitudinal cut is made as above, and then the stricture is carefully divided from within by means of a long, narrow-bladed, straight bistoury.

When the operation is being performed for the removal of a pedunculated non-malignant tumour, the location of the swelling is established by palpation or by passing the tube of an œsophagoscope downwards until the position and attachments of the pedunculated tumour can be seen. In some cases of this kind the narrowed pedicle can be cut through with a long pair of cutting forceps passed along the tube, and then the tumour extracted. When this procedure is not possible or not considered advisable, a longitudinal incision through the œsophageal wall is made directly over the tumour, its pedicle is surrounded by a silk ligature, and the tumour removed by cutting across the pedicle distal to the ligature.

(*d*) *Further treatment of the wound.*—If possible, the aperture in the œsophageal wall should be closed by the insertion of interrupted sutures of fine silk or catgut, one tier uniting the mucous and submucous layers, and a second one the muscular wall. If this can be done satisfactorily the external incision is closed in the usual manner, except at one extremity, where a small drainage tube or a strip of gauze is introduced and passed down to the wound in the œsophagus. If the incision in the œsophageal wall cannot be thoroughly closed, or if there has been ulceration, or the tube is in a septic condition, no attempt is made to close the aperture; the entire wound in these cases is packed with pads of gauze.

Œsophagostomy.—If it is wished to keep open the incision in the neck the margins of the aperture in the œsophagus are stitched to those of the external wound, a soft rubber tube is passed into the œsophagus, and the remainder of the incision is packed with gauze. The patient is fed through the rubber tube. This operation is generally known as œsophagostomy.

Œsophagectomy.—Œsophagectomy, or removal of a portion of the œsophagus, has been attempted by a number of surgeons in early cases of localised carcinoma of the œsophagus. The success, however, which has followed these operations has been very small, and on this account a description of the operation is not given.

Removal of a pouch or diverticulum of the œsophagus.—A localised pouch or diverticulum may occur in either the cervical or thoracic portions of the œsophagus; only the former is suitable for operative treatment.

Operation.—1. In One Stage.—The position of the pouch or diverticulum, as regards side and the structures in the neck, is first made out, usually by giving the patient a mixture containing bismuth subnitrate or barium sulphate, and afterwards taking an X-ray photograph, also the seat of the opening into or connection with the lumen of the œsophagus by examination with the œsophagoscope. The cavity of the pouch is emptied of its fluid contents by a tube passed down the œsophagus, in order to avoid as far as possible contamination of the wound during the further stages. An incision 4 inches long is made along the anterior margin of the lower portion of the sterno-mastoid muscle on the affected side of the neck. In most instances the pouch is located on the left side. The superficial tissues are divided and the sterno-mastoid muscle retracted laterally, and, if necessary, the sternal portion divided in the lower angle of the wound. The deep cervical fascia is divided for the entire length of the incision, and the infra-laryngeal

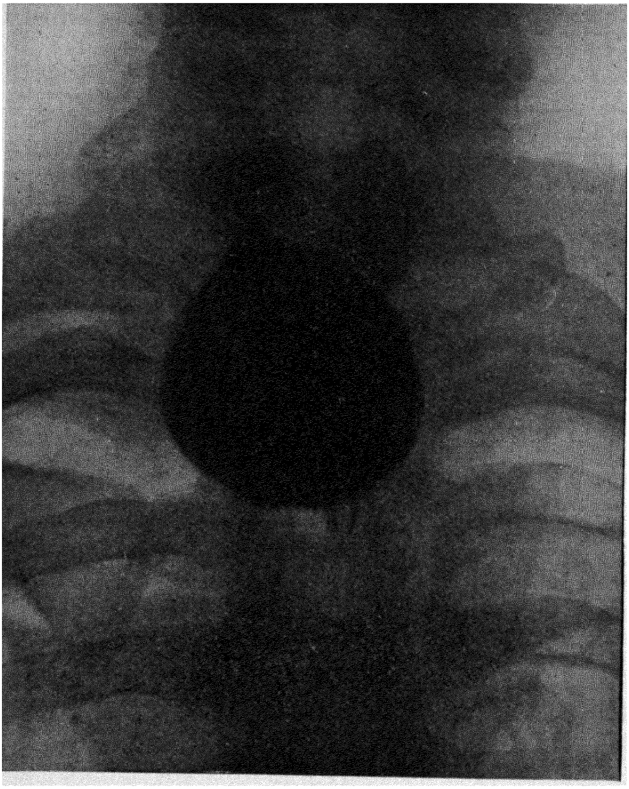


FIG. 308.—Skiagram of an œsophageal pouch. This shows the usual position of a pouch.

muscles retracted outwards or cut through if necessary. The structures in the carotid sheath are also retracted outwards, and the lateral lobe of the thyroid gland upwards. By these procedures the surface of the sac will become exposed in the bottom of the wound. By careful dissection it is separated from its surroundings, and the neck or communication with the œsophagus made out. When this is apparent it is transfixed and tied close to the œsophagus, and the distal portion removed by cutting with scissors. When there is a somewhat wide neck it may be necessary to transfix and ligature it in several places. The pouch having been removed, the bottom of the wound is sponged thoroughly clean, and then the opening into the œsophagus further closed with sutures. Usually it will be found advisable, when possible, to insert three tiers of sutures—one for the mucous membrane, the second for the muscular layer, and a third for the surrounding fibrous layer. Catgut of medium thickness is the best suture material for the purpose.

A gauze drain should now be passed down to the region of the sutured portion of the œsophagus, and brought out through one angle of the external wound. The remaining portion of the external wound is closed by sutures in the usual manner.

2. IN TWO STAGES.—*First Stage.*—The pouch is first exposed by the procedure detailed in the preceding operation, next it is brought out of the wound on a level with its attachment to the œsophagus, the space from which it has been taken is obliterated by the insertion of a few points of buried catgut suture, and finally its external surface is sutured to the margins of the upper portion of the skin incision, the lower portion of this incision being closed in the usual manner.

Second Stage.—Ten days later the sutures attaching the external aspect of the pouch to the margins of the upper portion of the skin are removed, and the pouch dissected free until the attachment to the œsophagus is reached. When this has been effected the neck of the sac is transfixed as in the previous operation, the sutures tied, and the distal portion removed. A further tier of sutures should be inserted so as to turn in the stump of mucous membrane towards the lumen of the œsophagus. The external wound is again closed, with the exception of a small portion through which a rubber drainage tube is inserted.

3. INVERSION AND SUSPENSION OF THE POUCH.—During the past few years I have practised the following operation in a certain number of patients with entire success.

Operation.—An oblique incision is made in the left side of the neck extending from a point behind the angle of the mandible to the upper margin of the sterno-clavicular articulation. The skin and fascial layers are divided and the anterior margin of the sterno-mastoid muscle exposed. This muscle is retracted outwards and the pouch exposed in a manner similar to that already described in the first operation. The infra-hyoid muscles are dissected free from their fascial surroundings, and lifted up by a retractor. Next, the pouch is passed underneath these muscles and placed in a fascial bed underneath the anterior margin of the sterno-mastoid, and fixed in this position by a number of points of catgut suture. The space from which the pouch has been taken is obliterated by buried sutures, and the infra-hyoid muscles also fixed by one or two points of catgut suture to the facial tissues in the region of the lower margin of the neck of the sac. Finally, the sterno-mastoid is replaced in position and the external wound closed.

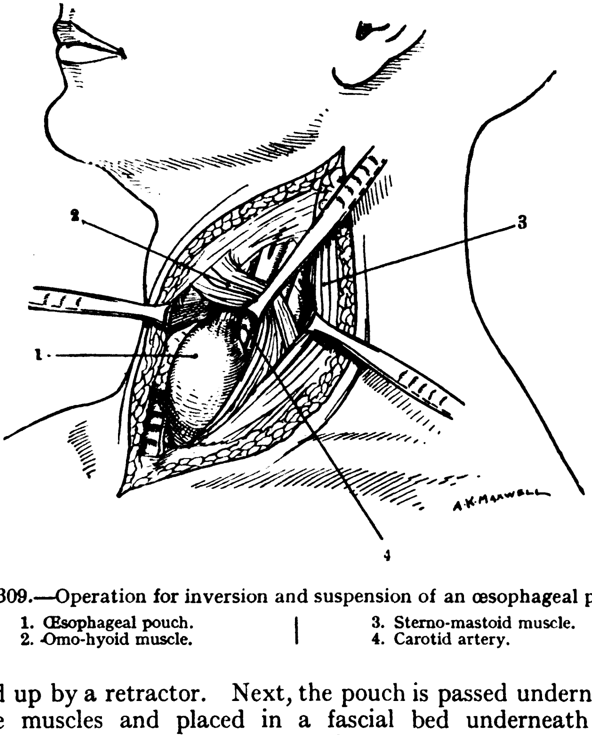


FIG. 309.—Operation for inversion and suspension of an œsophageal pouch

1. Œsophageal pouch.
2. Omo-hyoid muscle.
3. Sterno-mastoid muscle.
4. Carotid artery.

Comparison of the three operations.—The first operation is dangerous on account of the liability to septic contamination of the space from which the pouch has been taken. When this occurs, the septic condition is liable to spread downwards into the superior mediastinum and give fatal results. The operation in two stages is much safer and gives good results. The inversion operation is also a very safe operation, and when properly performed gives excellent results.

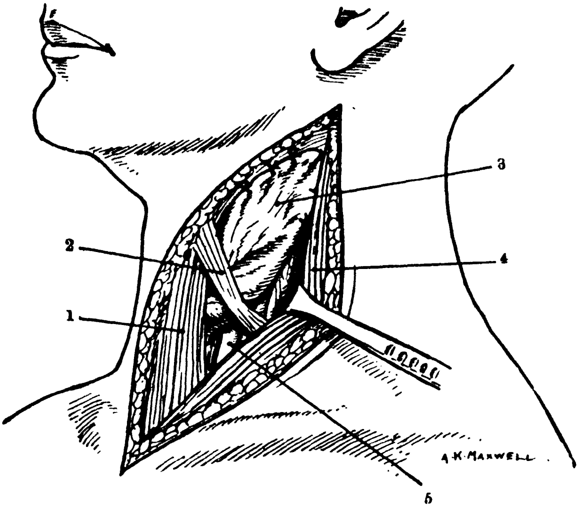


FIG. 310.—Operation for inversion and suspension of an œsophageal pouch

1. Sterno-hyoid muscle.
2. Omo-hyoid muscle.
3. Œsophageal pouch.
4. Sterno-mastoid muscle.
5. Common carotid artery.

CHAPTER XIX

OPERATIONS UPON THE LUNGS AND PLEURÆ

1. Operations upon the Lungs.
    - Pneumotomy.
2. Operations upon the Pleuræ.
    - Paracentesis.
    - Incision of pleura.
    - Estlander's operation, or Thoracoplasty.

Operation upon the Lungs

Pneumotomy.—By the term " pneumotomy " is understood that surgical operation which has for its object the making of an incision into the lung.

Indications.—(*a*) Localised abscess of the lung.

(*b*) Gangrene of the lung.

(*c*) Hydatid cyst of the lung.

(*d*) Foreign bodies within the lung which are giving rise to symptoms, and are so situated that they are capable of removal.

(*e*) Bronchiectasis, when the cavities are of considerable size, and increasing.

(*f*) Some forms of tuberculous cavity of the lung, especially when single, and not associated with tuberculous disease elsewhere.

Special instruments.—Periosteal elevator, rib forceps, rib retractors, aneurysm needles, trocar and cannula, drainage tube.

Position.—When the exact position of the affected portion of the lung has been defined, the patient is placed lying somewhat on the sound side, and with the affected side near or partially projecting beyond the edge of the operation table. The surgeon stands on the affected side of the patient, and the assistant opposite to him.

Operation.—The position of the abscess, cyst, etc., is made out, an exploring syringe being used if necessary. An incision is made over the middle of the affected area, so that it is parallel with the underlying intercostal space or rib.

This incision will be usually from 3 to 4 inches in length. It is deepened until the external intercostal muscle is exposed. If the space laid bare is wide enough for the proposed treatment, the intercostal muscles are divided in the line of the original incision, care being taken to keep near the lower border of the space, so as to avoid injury to the intercostal vessels; the parietal pleura covered by the endothoracic fascia is then exposed. If the parietal and visceral layers of the pleura are adherent at this point an incision is made into the lung tissue, until the cavity or cyst is reached. The cavity may be opened by first pushing inwards the needle of the exploring syringe, and then passing the blades of a pair of dressing forceps along the needle.

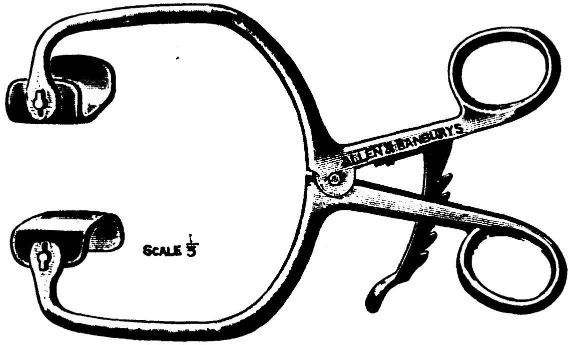


FIG. 311.—Retractor for separating ribs in operation upon lungs or pleuræ.

When the lung is not adherent to the chest wall the pleural cavity is opened by incising the parietal pleura. Contamination of the pleural cavity must be avoided, either by stitching the lung and visceral pleura to the opening in the parietal pleura, or by packing with tampons of gauze. In some cases it may be advisable to attempt to obliterate the cavity by inducing the formation of adhesions between the visceral and parietal layers of the pleura.

When the intercostal space is narrow a portion of one or more ribs should be resected and the margins of the incisions drawn apart by suitable retractors (Fig. 311).

The cavity of the abscess or cyst having been opened, the contents are allowed to exude. In the case of a hydatid cyst, the margins of the incision in the cyst should be stitched to those of the parietal incision, and drainage established after removal of the endocyst; and in the treatment of abscesses or gangrenous cavities, after the contents have been removed a large drainage tube should be inserted. This tube should be of soft rubber, and not too long, otherwise it may cause laceration of the lung tissue forming the boundaries of the cavity, and give rise to hæmorrhage.

OPERATIONS UPON THE PLEURA

Paracentesis thoracis, or thoracocentesis.—This operation has for its object the removal of pus, pleural exudation, or other fluid collection from the interior of the thoracic cavity, usually from within the pleura.

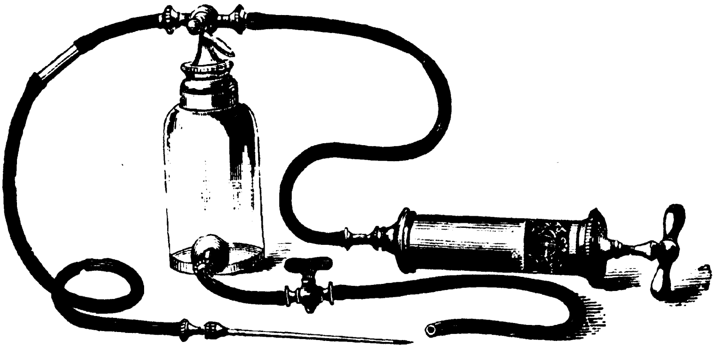


FIG. 312.—Paracentesis thoracis. Aspirator with vacuum bottle and exhausting syringe.

Indications.—(*a*) Collections of fluid within one or other pleural cavity, which in most instances are either serous or purulent. The differential diagnosis of these conditions is not always possible without exploratory puncture with the needle of an aspirator or an exploring syringe.

(*b*) Hydatid or other cysts of the lung, and localised abscesses of the lung, as an aid to their diagnosis, and in order to facilitate the performance of a more extended surgical operation.

Special instrument.—Aspirator or exploring syringe.

Position.—The patient is placed lying somewhat on the sound side, with the affected part of the chest near the edge of the bed. The surgeon seats himself behind the patient, opposite the part of the thoracic wall it is proposed to aspirate. A general anæsthetic is not necessary, but the local injection of novocain is advantageous.

Operation.—The exact locality of the fluid collection within the chest having been defined by percussion, a very small incision is made through the skin over one of the intercostal spaces. It is usual to select a space directly over the central part of the fluid collection. The thumb-nail of the left hand is pressed against the superior margin of the rib which forms the inferior boundary of the selected space, a small notch in the skin is made with the scalpel, and then the exploring needle, or the needle of the aspirator, is pushed inwards until the underlying cavity is reached. Care must be taken to push the needle well into the fluid-containing space, but not beyond this, otherwise either the lungs or some other structure will be damaged. Often the pleura bounding the fluid-containing space is much thickened by the deposition of layers of fibrin, which may be a slight obstacle to the needle passing into the cavity. When the needle has entered the cavity, a condition which, generally, can be recog-

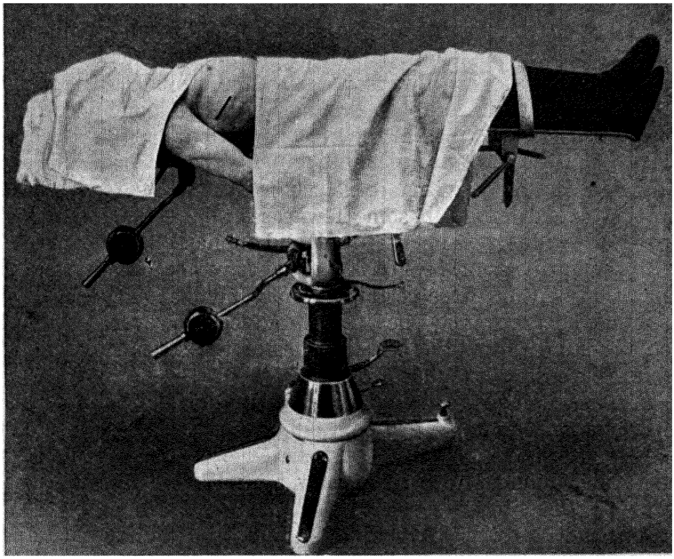


FIG. 313.—Position of patient, and line of external incision, in incision of pleura with resection of a portion of rib.

nised by the sense of diminished resistance at the point of the instrument, it is connected with the syringe or aspirator, which latter should have been already exhausted.

- The fluid collection is allowed to flow out slowly, in order to avoid, if possible, the occurrence of syncope, an accident which may happen.

During the entire procedure the strictest aseptic precautions must be observed, otherwise a non-purulent collection of fluid may be converted into a purulent one, owing to the entrance of septic micro-organisms with the needle.

Serous collections within the pleural cavity can usually be cured by this operation, but when we have to deal with an empyema it is nearly always necessary to provide a freer exit for the pus, and to establish drainage. This is done according to the method described in the next operation.

Surgical treatment of empyema.—To secure efficient drainage of an empyema it is usually necessary to resect a portion of a rib, but in some few cases where the intercostal spaces are wide this is not essential, and an incision made parallel with the long axis of a space is all that is required. The site of operation depends, to a certain extent, upon the exact localisation of the empyema, the usual practice, however, being to remove subperiosteally 1½ to 2 inches of the seventh or eighth rib in the posterior axillary line.

Position.—The patient is placed in the dorsal position, with the shoulders slightly raised on a pillow, and the affected side of the chest projecting well beyond the edge of a somewhat high operating table. The surgeon seats himself on a low stool well below the level of the patient.

Anæsthetic.—It is best to employ nitrous oxide gas and oxygen.

Special instruments.—Curved periosteal elevator, and a pair of bone scissors or shears with short, strong blades.

Operation.—An incision, 2 to 2½ inches in length (Fig. 313), is made over the selected rib, midway between its upper and lower borders, and in the line of its long axis. All the tissues are divided down to the bone, and the periosteum incised in the line of the original wound.

The thickened periosteum is now separated from the superficial and deep aspects of the exposed portion of the rib by a periosteal elevator, and its edges picked up above and below by pressure forceps.

A curved periosteal elevator (Fig. 314) is now passed in deep to the rib in order to protect the periosteum, and carried to one or other extremity of the wound. The bone is then divided in this position by means of bone forceps, the instrument being held at right angles to the surface of the chest wall, with the points of both blades resting upon the flattened surface of the elevator. This is repeated at the other end of the wound, and in this manner about 2 inches of rib are resected. An assistant holds apart the periosteal edges by means of the pressure forceps previously applied, and the empyema is opened by an incision, about 1 in. long, through the thickened periosteum and parietal pleura. The opening is made parallel with the original wound, and midway between the cut edges of the periosteum, so as to avoid the intercostal vessels.

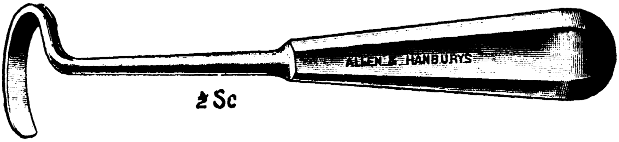


FIG. 314.—Curved periosteal elevator for separation of periosteum from the deep aspect of a rib.

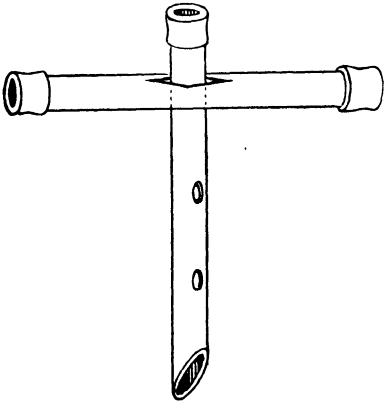


FIG. 315.—T-shaped drainage tube, for drainage of pleura. It is made out of two pieces of rubber tubing, the vertical limb being passed through a slit in the transverse one. The cuff prevents slipping of the tubes.

If the empyema is not of long standing and the lung is capable of expansion, the cavity should be carefully sponged dry and the thoracic wall closed in layers. In an old-standing case, however, as soon as the greater part of the fluid has been evacuated, a moderately large drainage tube is inserted and fastened in position, and dressings applied.

After-treatment. — The dressings and tube should be renewed daily, and, after the first few days, the latter should be gradually shortened and replaced by one of smaller calibre. If the empyema is due to a pneumococcal infection it is not advisable to employ irrigation, and the patient should be nursed with his shoulders propped up and lying partially on the affected side to facilitate thorough drainage.

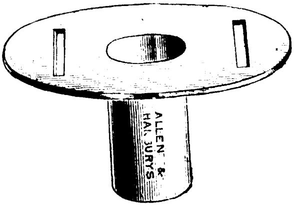


FIG. 316.—Metal empyema drainage tube.

Excision of part of the bony wall of an empyema cavity Thoracoplasty — (Estlander's operation).—Removal of a considerable portion of the bony chest wall is necessary in those cases of long-standing empyema in which the cavity does not spontaneously close.

Operation.—The limits of the cavity which it is proposed to close having been ascertained as far as possible by percussion, auscultation, and examination with probes or sounds, a semilunar or U-shaped flap, comprising all the soft tissues of the chest wall superficial to the ribs, is reflected, the attached base of the flap being in most cases above (Fig. 317). In lifting up

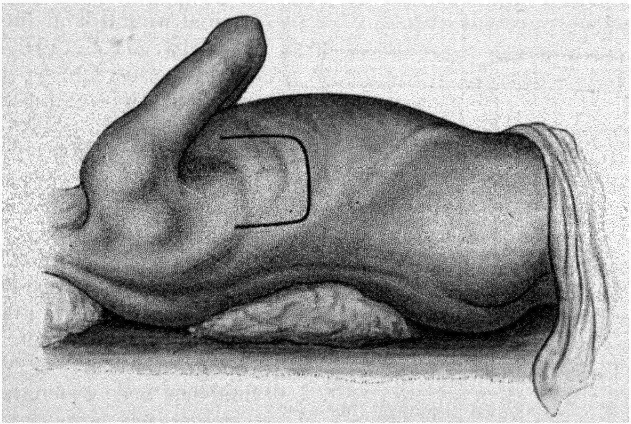


FIG. 317.—Excision of part of chest wall.
(External incision.)

the muscles from the ribs, care must be taken that no pe teum is raised with it. It is safer, in fact, to leave a s portion of the muscle attached to the rib. All bleeding having been arrested by the application of pressure forceps, portions of the exposed ribs are removed. The amount of each which is excised depends entirely on the size of the cavity which it is proposed to close; often it is necessary to remove portions of four, five, or six ribs, pieces from 2 to 5 inches long being taken from each. The longest portions of rib are taken from over the middle of the empyema cavity.

After portions of the ribs have been removed and the cavity thoroughly exposed, it will usually be found advisable to take away the thickened part of the parietal pleura which forms the external boundary of the cavity. In order to do this satisfactorily, it will be necessary to ligature some of the intercostal arteries along the anterior and posterior margins of the exposed space.

When the cavity has been laid thoroughly open in this manner, its interior is well washed out, all traces of pus and lymph being removed, if necessary, by scraping with a Volkmann's spoon.

The entire cavity is then packed with strips of gauze, one extremity of each strip protruding from the lower part of the wound. This having been done, the external flap of soft tissues is replaced and fixed in its former position by the insertion of a number of interrupted sutures. The lower part, however, is left open for the exit of the extremities of the tampons of gauze. Finally, an absorbent dressing is applied.

After-treatment.—At the expiration of from twenty-four to forty-eight hours the gauze packing is removed from the interior of the chest, the cavity syringed out with an antiseptic solution, and then packed as before. This is repeated periodically until the wound is healed.

Some surgeons advise that, instead of making a large "U-shaped" flap of soft tissues, a separate incision should be made over each rib of which a portion is to be removed. In my opinion, however, the above operation is more satisfactory, since it enables a complete examination of the interior of the cavity to be made, and allows the removal of thickened pleura and the layers of fibrous lymph which are usually met with.

CHAPTER XX

OPERATIONS UPON THE PERICARDIUM AND HEART

PARACENTESIS OF THE PERICARDIUM.
INCISION.
TREATMENT OF WOUNDS OF PERICARDIUM AND HEART.
CARDIOLYSIS.

Paracentesis of the Pericardium.—This operation consists in withdrawing, by means of an aspirating trocar and cannula, collections of fluid from the pericardial cavity.

Indications.—(*a*) As a means of diagnosis in some cases of distension of the pericardium.

(*b*) For the withdrawal of a serous effusion of the pericardium which is not amenable to ordinary medical treatment, and in which the amount of fluid is increasing.

Special instruments.—Aspirating trocar and cannula.

Position.—The position of the patient will depend upon his condition ; usually it will be more convenient to perform the operation with the patient sitting up. The operator sits on the left side of and opposite to the patient.

Operation.—A point is selected over the fifth left interspace, either outside the line of the internal mammary artery—that is to say, about 1 inch from the margin of the sternum—or on the medial side of this vessel, close to the lateral margin of the sternum.

A small incision is made in the skin with the scalpel, and the trocar and cannula carefully pushed inwards until the pericardial cavity is reached ; this is recognised by the sense of diminished resistance to their passage. The trocar is withdrawn, and the cannula connected with the vacuum, and the contained fluid evacuated.

When the cavity has been emptied the cannula is taken out and the aperture covered by a small dressing.

If the fluid within the pericardium is found to be purulent, aspiration is not sufficient, but incision and drainage must be performed.

Incision of the Pericardium.—*Indications.*—(*a*) Purulent pericarditis, and (*b*) wounds of the heart.

Position.—As for the preceding operation.

Operation.—An incision 2 to 2½ inches long is made over the fifth or sixth left intercostal spaces parallel with the costal cartilages, commencing at the lateral margin of the sternum.

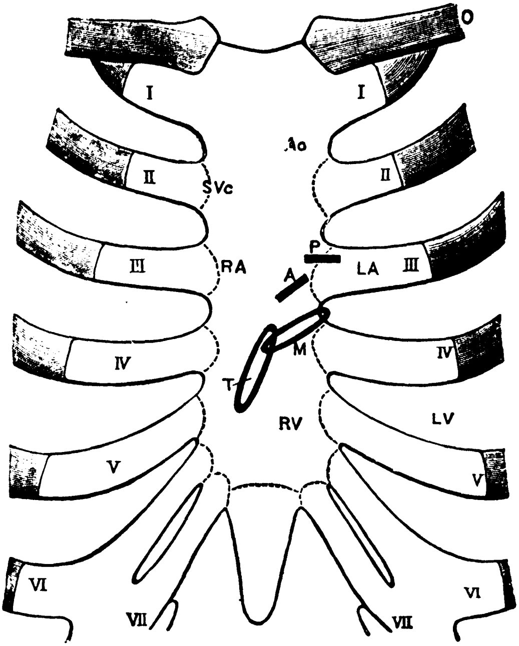


FIG. 318.—Schematic representation of relations of pericardium and heart to anterior thoracic wall.—CUNNINGHAM.

The skin, fasciæ, pectoralis major, and intercostal muscles are divided, and a portion or the whole of the sixth costal cartilage cut away if requisite, care being taken to avoid the internal mammary artery. This blood vessel lies at right angles to the incision, and at about ½ inch from the lateral margin of the sternum.

If the internal mammary vessels are in the way, an aneurysm needle should be passed underneath them, when they can be ligatured in two places and divided between. The fibres of the transversus thoracis are next separated or cut through, and if necessary the lateral margin of the sternum may be cut away with bone forceps in order to give more room. The margins of the left pleura and lung are pushed outwards if exposed, and then the exposed parietal pericardium is divided in a vertical direction with a scalpel. The blades of a pair of dressing forceps are passed into the wound and separated. By this means free exit is given to the pus.

If the contained pus is very offensive it may be desirable to irrigate the pericardial cavity with warm saline solution.

All the pus having been removed, a soft rubber drainage tube is passed into the cavity, and dressings applied.

Treatment of wounds of the Heart and Pericardium.—*Indications.*—The indication for the adoption of surgical treatment in this connection is direct local evidence of injury to the heart or pericardium, associated with immediate and continued enlargement of the cardiac dullness and embarrassment of the heart's action ; or the diagnosis, from these symptoms, of the extension of some remote or indirect injury to this vicinity.

Special instruments.—Periosteal elevator, bone forceps, Hey's saw, " lion " forceps.

Position.—The position must depend on the patient's condition, who, if necessary, must be allowed to sit up, well supported from behind. The surgeon stands where most convenient to himself under the circumstances. A local or general anæsthetic may be administered.

Operation.—The proceedings may be carried out in the following stages :—

(*a*) *Skin incisions and reflections of flaps.*—A vertical incision is made 2 inches to the left of the left border of the sternum, from the lower border of the fourth rib to the lower border of the sixth. Transverse incisions are made at the extremities of this and at right angles to it, and the resulting flaps reflected, on the one side up to the lateral border of the sternum, and on the other side for some 2 or 3 inches.

(*b*) *Resection of thoracic wall.*—At the lateral limits of the area thus exposed, the fifth and sixth ribs are cut through with bone forceps, their muscular and fascial connections with the ribs above and below secured and together turned inwards, the costal cartilages being divided if necessary.

(*c*) *Examination of pericardium.*—Any blood clot or fluid is now sponged away, and, if necessary, the left pleura retracted outwards. Should a wound in the pericardium be found, it may then be sutured. Should further examination be deemed necessary, this wound is enlarged and the pericardial cavity exposed ; or, if no wound be visible, the pericardium may be incised.

(*d*) *Treatment of pericardial cavity and suture of heart and pericardium.*—The pericardial cavity is then sponged clean, and any wound on this aspect of the heart united with interrupted sutures of catgut, passing through the heart muscle but avoiding its cavity.

The wound in the pericardium is then sutured, the edges being well everted.

(*e*) *Closure of external wound.*—The resected portion of the thoracic wall may then be replaced and sutured in position, and the skin incision closed.

Cardiolysis.—The object of this operation is division or separation of fibrous bands joining the fibrous pericardium to adjacent structures or tissues, or of adhesions which fix together the visceral and parietal layers of the serous pericardium, in order to free the heart from mechanical obstructions to its movements. The early stages of the operation are similar to those just described in connection with exposure of the pericardium in the treatment of injuries. After exposure of the outer aspect of the pericardium, any fibrous bands which can be detected are cut through and then the cavity is opened. Fibrous adhesions or bands are sought for and when discovered within the cavity are cut across, and, if of any appreciable length, removed, after division, close to the cardiac surface and to the inner aspect of the pericardium. Any hæmorrhage which may be present is completely arrested by ligature, and then the wound in the pericardium is closed by sutures of catgut and afterwards the external incision.

Moderate success in well selected cases has been obtained by this operation. Great care, however, is requisite not to damage unnecessarily the cardiac tissues during the treatment of the adhesions.

CHAPTER XXI

OPERATIONS UPON THE CRANIUM

TREPHINING—
- For fracture of the skull.
- For extra-dural abscess or hæmorrhage.
- For cerebral tumour or cyst.
- For cerebral abscess.
- For cerebellar tumour or cyst.
- For cerebellar abscess.
- Tapping and drainage of the lateral ventricle.
- For the removal of foreign bodies within the skull.
- For epilepsy.

TEMPORARY RESECTION OF THE SKULL.

CRANIECTOMY OR LINEAR CRANIOTOMY.

DECOMPRESSION.

IN order to expose any of the cranial contents, for the purpose of performing upon them a surgical operation, it is necessary to remove a part of the bony brain case. This is usually done by the aid of an instrument called a trephine. In some cases, however, a chisel and a mallet will be more useful; and in others, especially in those cases in which it is wished to remove a large piece of the cranial vault, a small circular saw, driven by an electric or other form of motor, or a wire saw (Gigli), will be the most efficient.

The operation of trephining and of resection of a portion of the cranial vault will be considered generally, since the methods of procedure in the different operations upon the cranium, which involve the removal of bone, are somewhat similar.

It will be convenient first of all to consider—(1) The important depressions and prominences which can be felt and seen on the surface of the cranium; and (2) the points which may be determined by means of these; and then (3) the underlying cranial contents which these points serve to indicate.

The glabellar fossa.—This is a depression situated about a quarter of an inch above the root of the nose at the junction of the frontal and nasal bones.

The external occipital protuberance, or inion.—This is a prominence (varying a great deal in size) situated in the middle line at the junction of the vault and the base of the skull posteriorly ; the *superior curved line* of the occipital bone extends from it laterally in each direction forwards to the base of the mastoid process.

The mastoid process.—This conical-shaped prominence is situated immediately behind the ear, with the base upwards and apex downwards and forwards, whilst the whole extent of its posterior border is easily definable.

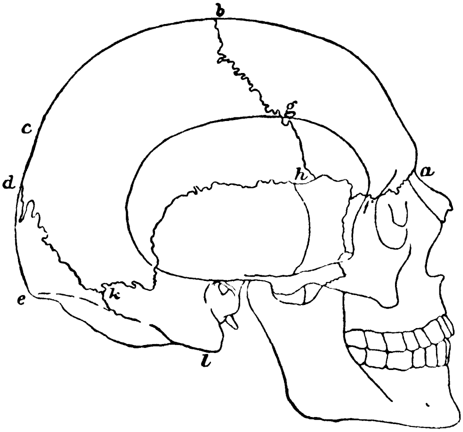


FIG. 319.—Trephining. Skull showing positions of important bony points, etc.

a. Glabellar fossa.
b. Bregma.
c. Position of parietal foramina.
d. Lambda.
e. Inion, or external occipital protuberance
f. Lateral angular process of frontal bone.
g. Stephanion.
h. Pterion.
i. Mastoid process.
k. Asterion.

The external auditory meatus.—This lies immediately in front of the upper portion of the base of the mastoid, and its cartilaginous continuation forms a sufficiently accurate guide to its bony margins.

The suprameatal triangle (*MacEwen's triangle*).—This is a small more or less sharply defined depression, immediately above and behind the auditory meatus.

The zygoma is the bridge of bone stretching forwards, horizontally, from the anterior margin of the auditory meatus to

The malar prominence, which is situated at the lateral and lower angle of the orbit.

The external angular prominence of the frontal bone lies above the malar prominence, and constitutes the upper and lateral angle of the orbit.

The bregma.—This spot is situated on the vertex of the skull about the bisection of a line drawn vertically between the two external auditory meatuses ; whilst, if a point be taken about half an inch posterior to the bisection of the distance between the glabella and external occipital protuberance a spot will be found that may be termed the *Rolandic* spot. This also corresponds with the upper point of trisection in a line drawn between the bregma and external occipital protuberance ; the lower point of trisection in this line being one to which reference will be made later.

The pterion is a spot in the temporal fossa that coincides with the point of bisection of a line drawn horizontally backwards and parallel with two zygoma, from the lateral (external) angular process of the frontal bone to a point vertically above the corresponding external auditory meatus.

It may also be found by drawing a line vertically upwards from the centre of the zygoma, the pterion being situated at the point where this line meets the above-mentioned horizontal line ; or, if a square be completed on a line drawn between the lateral angular prominence of the frontal bone and the malar prominence, with the upper border of the zygoma as a second side, the pterion will correspond with its postero-superior angle.

The coronal suture lies between the bregma and pterion ; where this suture crosses the temporal crest is the spot known as the *stephanion,* a point the same distance above the pterion as the pterion is above the zygoma, and in the same vertical line.

The sagittal suture lies in the middle line for the anterior two-thirds of the distance between the bregma and inion ; its posterior extremity corresponding with the lambda, which can often be felt as a prominence opposite the lower point of trisection in this line.

The limits of the *cerebrum* may be marked out by drawing a line from a quarter of an inch above the external occipital protuberance behind, to the base of the mastoid process ; thence to the upper border of the external auditory meatus ; next to the lateral angular process of the frontal bone in a curved direction, the convexity being towards the prominence of the zygomatic bone; and finally, medially to the middle line, a quarter of an inch above the depression at the root of the nose.

The upper limits of the *cerebellum* can be defined by drawing

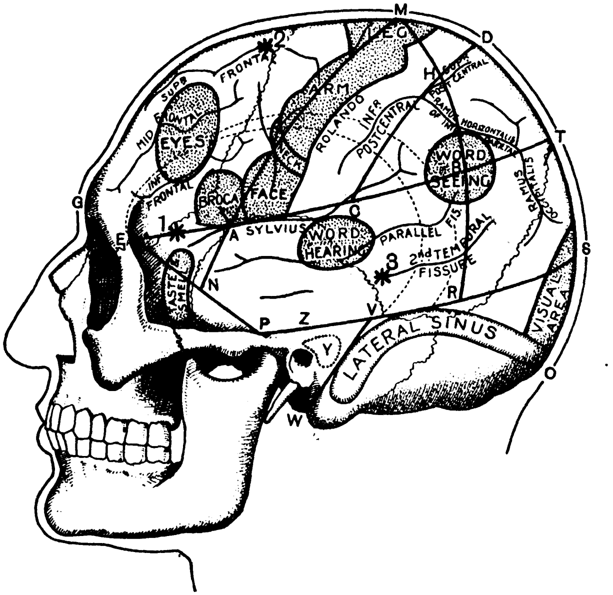


FIG. 320.—Cranio-cerebral topography.—CUNNINGHAM.
Relations of the motor and sensory areas to the convolutions and to Chiene's lines.

G. Glabella.
O. Inion.
M. Mid-point between G and O.
T. Mid-point between M and O.
S. Mid-point between T and O.
E. Lateral angular process of frontal bone.
P. Root of zygoma (pre-auricular point).
N. Mid-point of E–P.
R. Mid-point of P–S.
C. Mid-point of A–B.

C–D. is drawn parallel to A–M.
Z. Post-auricular point.
V–W. Guide to anterior limit of transverse (lateral) sinus.
Y. Mastoid antrum.
*1. Site at which sub-arachnoid space may be opened.
*2. Site for draining lateral ventricle (Kocher).
*3. Site for draining lateral ventricle (Keen).

a line a quarter of an inch below the superior curved line on the occipital bone, and parallel to it, forwards to the centre of the base of the mastoid process; the lower limit is situated about 1 inch below the line, but, on account of the soft parts of the neck, can be less accurately marked out.

The division between these two main portions of the brain also corresponds with the attachment of the tentorium cerebelli. The divisions between the cerebral lobes are easily defined; the median line between the glabella and external occipital protuberance indicating the division between the cerebral hemispheres and the two halves of the cerebellum, and also the situation of the falx cerebri and falx cerebelli.

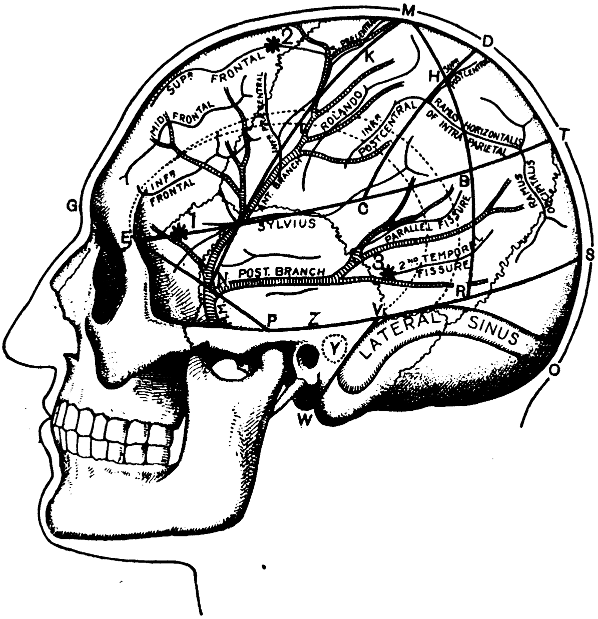


FIG. 321.—Cranio-cerebral topography.—CUNNINGHAM.
The meningeal arteries are marked transversely, the sulci black, and the sutures serrated.
(The references are the same as Fig. 320.)

The division between the frontal and parietal lobes corresponds with the central sulcus of Rolando, which may be marked out by drawing a line from the Rolandic spot forwards and downwards at an angle of 67·5 with the anterior portion of the median line from glabella to inion, the former line also corresponds with that joining the Rolandic spot and pterion.

The line of junction of the parietal and occipital lobes is indicated by joining the lower point of trisection in the line between the bregma and inion with the external auditory meatus; the upper part of this line corresponding to the external parieto-occipital fissure. The separation between the temporo-sphenoidal and parietal lobes corresponds to the line drawn horizontally backwards from the lateral angular process.

The pre- and post-central fissures lie respectively half an inch in front and behind the central sulcus of Rolando, and thus the whole Rolandic area may be indicated.

The main lateral fissure of the brain (Sylvian) reaches the surface of the brain opposite the pterion in three limbs: from this point, extending vertically upwards half an inch; directly forwards 1 inch; whilst its posterior ramus runs directly backwards in the horizontal line in which the pterion lies, till vertically opposite the external auditory meatus, when, curving slightly upwards for about 1 inch, it terminates.

The superior sagittal sinus (*superior longitudinal sinus*) lies usually immediately to the right of the median glabella-inion line (*for its entire extent*), the *inferior sagittal sinus* (*inferior longitudinal sinus*) lies opposite the anterior two-thirds, and the *straight sinus* opposite the posterior third of the line.

The transverse sinus (*lateral sinus*) lies opposite the superior curved line of the occipital bone, not extending further forwards than the centre of the base of the mastoid process, where it then curves downwards and forwards to a point immediately below the external auditory meatus.

The anterior branch of the middle meningeal artery is best sought at the pterion, and its *posterior branch* at a spot vertically above the mastoid process in a line drawn backwards horizontally through this point; whilst the main trunk is opposite a point a finger's-breadth above the centre of the zygoma. The supra-meatal (MacEwen's) triangle indicates the situation of the *mastoid antrum*.

Professor Chiene's method of demarcating the different portions of the brain and intra-cranial contents is illustrated in Figs. 320 and 321. The following fixed points are taken, viz.:—

G. Glabella.
O. External occipital protuberance.
M. The mid-point between G and O.
T. The three-quarter point between G and O.
S. The seven-eighth point between G and O.
E. The lateral angular process of the frontal bone.
P. The root of the zygoma.

These points having been ascertained, E—P, P—S, and E—T are joined together. The lines E—P and P—S are bisected at points N and R, and lines drawn from M to N and M to R. The line A—B is bisected at C, and a line C—D is drawn parallel to A—M.

The line M—A demarcates the superior and inferior pre-central sulci, and is known as the pre-central line.

The line E—T, called the oblique or Sylvian line, intersects the pre-central line at the point A, which overlies the pterion and corresponds to the Sylvian point of the lateral fissure, and to the anterior division of the middle meningeal artery. The termination of the Sylvian line, at the three-quarter point T, overlies the external parieto-occipital fissure.

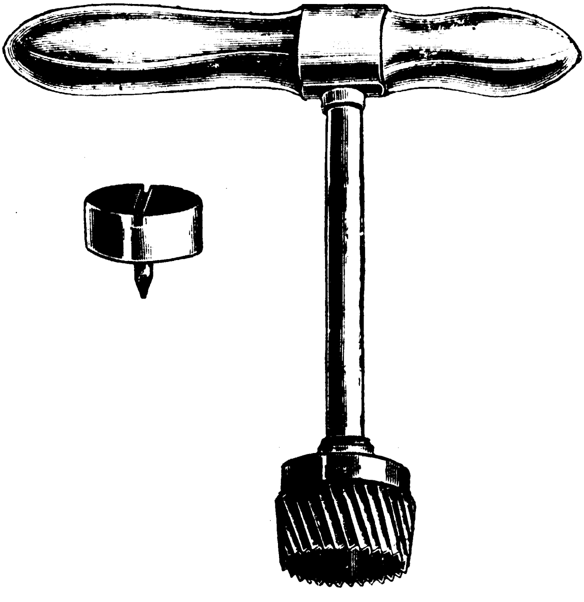


Fig. 322.—Trephining. Conical hand trephine with central pin fixed on a circular piece of metal, which fits in the interior of the trephine, and is easily removed.

By joining T—R, R—O a triangle is mapped out which delimits the outer surface of the occipital lobe; the line T—R corresponds to the lambdoidal suture, whilst R—O corresponds to or lies a little above the tentorium and the upper border of the lateral sinus.

The parallelogram A—M—D—C overlies the Rolandic area, and the pentagon A—B—R—P—N maps out the temporal lobe with the exception of its apex.

Trephining. — *Special instruments.* — Periosteal elevator (straight and bent), bone forceps, gouge forceps, small saw (Hey's), trephine, trephine brush, quill, chisel and mallet, wire saw (Gigli's), or a circular saw driven by a motor (if it is necessary to remove a large piece of bone), fine-toothed forceps, sponge holders, trocar and cannula.

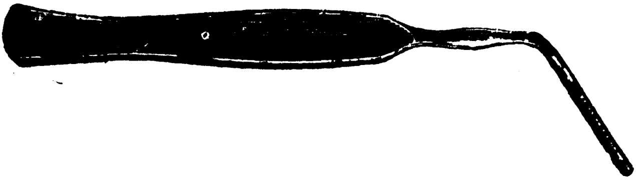


FIG. 323.—Trephining. Periosteal elevator.—HORSLEY.

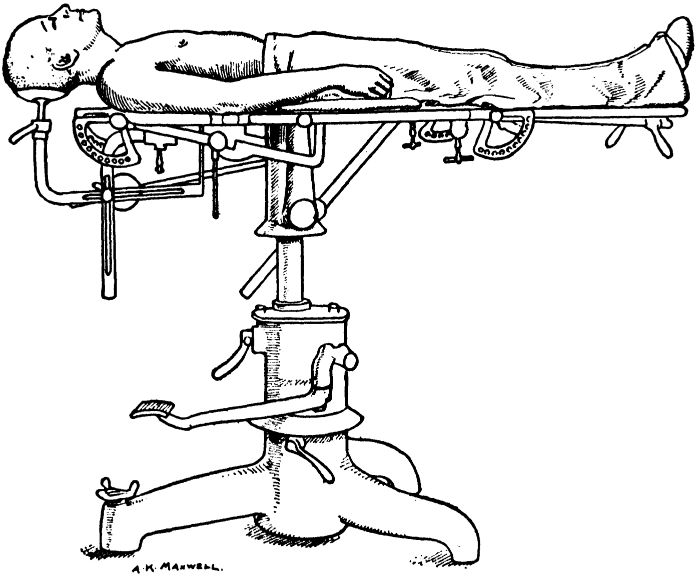


FIG. 324.—Operation table with head-rest for cranial operations.

Position.—The patient is placed in the dorsal position for nearly all operations upon the cranium, with the head turned towards the sound side. The operation table should be of moderate height, so as to allow ready access to all parts of the wound.

For many operations, especially those upon the cerebellum, or in the occipital region, or during which it is desirable to irrigate the field of operation, it is very convenient to have an operation table with a special head-rest. Fig. 324 is a useful form. In any case the head portion of the table should be inclinable.

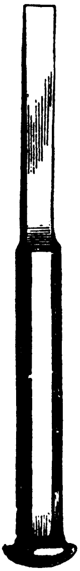


FIG. 325.—Trephining. Chisel with straight edge.

Operation.—The operation of trephining may be divided into the following stages, namely—(*a*) Demarcation, on the external surface of the cranium, of the part of the cranial contents which it is proposed to lay bare; (*b*) formation of a flap consisting of the soft structures of the scalp; (*c*) removal of a portion of the cranial bony vault; (*d*) incision of the membranes of the brain, and exposure of the brain surface, in those cases, such as cerebral tumour or abscess, in which it is necessary to go beyond the membranes; (*e*) special treatment of diseased part, such as evacuation of pus from a cerebral abscess, or excision of an intra-cranial tumour; (*f*) closure, complete or partial, of incision in membranes, and further treatment of wound; (*g*) after-treatment.

In the operations of trephining and of osteoplastic resection of the skull the lines of the meningeal sinuses should be avoided as far as possible, as well as the region of the bony sutures. It is not always possible, however, to avoid the sutures.

(*a*) *Demarcation on the external surface of the cranium of the part of the cranial contents which it is proposed to lay bare.*—This can be effected by paying attention to the points which have been discussed under anatomical considerations.

(*b*) *Formation of scalp flap.*—The part to be operated upon having been determined, a semicircular incision is made in the scalp, which comprises this area, and is so situated that the base of the flap is towards the base line of the brain, and the convexity towards the vertex of the skull. The soft structures of the scalp, including the pericranium, should be divided with the scalpel right down to the bone. The periosteal elevator is taken, and the periosteum is detached from the bone, and the flap of soft structures turned down. Often it is desirable and advantageous to make the scalp flap comprise the soft tissues of the scalp without the pericranium, and when the flap has been turned down to make a crucial incision through the pericranium, the centre of which is situated where the trephine is to be first applied. This flap is held out of the way by a retractor or a silk suture passed through its highest point. All bleeding from the vessels of the scalp is arrested by ligature or pressure forceps. The circulation in the scalp may be controlled by placing a rubber band tightly round the head before commencing the operation.

(*c*) *Removal of a portion of the bony cranium.*—(1) *By the use of a trephine.*—A trephine is taken, of the shape shown in Fig. 322. The centre pin is introduced, and placed on the centre of the piece of bone which it is wished to remove. The pin is thrust into the bone by a pushing and rotatory movement, and then by a series of to-and-fro circular movements with the hand, the teeth of the instrument are made to cut a circular groove in the bone. When a definite groove has been made the trephine is taken out of the wound, the central pin is removed, and the instrument is again introduced and the circle of bone gradually sawn through. Care must be taken to avoid using the saw in a jerky manner, otherwise much longer time will be taken in removing the circle of bone. From time to time, as the sawing proceeds, the trephine should be taken from the wound, and the bone dust brushed out of the groove in the bone and from the teeth of the instrument. When the bone has been nearly cut through, the crown can be lifted out either by a side-to-side movement with the trephine, or by lifting it up with a periosteal elevator. If the removal of one crown of bone does not give sufficient space a second or even a third may be removed,

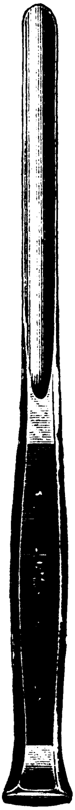


FIG. 326.—Trephining. Chisel grooved.

has already been given. The dura mater is best opened by making a semilunar incision in it, the convexity being towards the vertex. The margins of this incision should be a short distance internal to those of the incision in the bone, so as to allow of closure later. When the flap of dura mater so marked out has been turned down, any cyst or abscess in the subdural space may be dealt with. If it is necessary to proceed further, the arachnoid membrane is incised. This is normally a very thin membrane, and lies in close contact with the pia mater. It may, however, be thickened in diseased conditions. The pia mater, a very vascular membrane, is now laid bare and can be incised if requisite, so as to expose the cortex of the brain.

(*e*) *Removal of diseased brain tissue, etc.*—In cases of cerebral abscess, cerebral tumour, or foreign body in the brain, or tapping of the lateral ventricle, the cerebral operation proper can now be carried out. Details of these procedures are given under the headings of the separate operations.

(*f*) *Further treatment of wound.*— In a non-septic case, when the diseased portion or the foreign body has been removed, all bleeding from the surface of the brain is arrested, and the margins of the incision in the membranes are united by the insertion of fine catgut sutures. Next, the portions of bone which have been removed are replaced in their original position, and finally the scalp flap is accurately stitched over them and dressings applied. In septic cases, drainage must be established. The portions of bone removed are not replaced in cases of this kind. Part of the external wound is left open for the exit of the drainage tube, whilst the remainder is closed in the ordinary manner.

(*g*) *After-treatment.*—The patient must be kept very quiet after the performance of an operation on the brain. In non-septic cases the dressings are left on for a week, and then taken off and the stitches removed. In suppurating cases the dressings must be frequently changed, so as to avoid as far as possible the accumulation of pus or septic fluid within the wound.

For fracture of the skull.—*Indications.*—(*a*) *Punctured fractures of the skull.*—All cases of punctured fracture of the skull should be trephined, and an examination made of the extent of the injury, since in this form of fracture the inner table of the skull is very often driven inwards and splintered, whilst the external wound is small and insignificant.

(*b*) *Compound depressed fractures.*—It is the safest plan to has already been given. The dura mater is best opened by making a semilunar incision in it, the convexity being towards the vertex. The margins of this incision should be a short distance internal to those of the incision in the bone, so as to allow of closure later. When the flap of dura mater so marked out has been turned down, any cyst or abscess in the subdural space may be dealt with. If it is necessary to proceed further, the arachnoid membrane is incised. This is normally a very thin membrane, and lies in close contact with the pia mater. It may, however, be thickened in diseased conditions. The pia mater, a very vascular membrane, is now laid bare and can be incised if requisite, so as to expose the cortex of the brain.

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(*b*) *Compound depressed fractures.*—It is the safest plan to operate on all cases of this kind, owing to the fact that often particles of dirt which have been carried in at the time of the injury are liable to escape notice and become the cause of suppuration. This is especially the case in bullet wounds.

(*c*) *Foreign bodies* embedded in the bones of the cranial vault, and possibly extending into the brain substance or penetrating the membranes.

(*d*) *Simple depressed fractures of the skull.*—In adults it is the best and safest plan of treatment to elevate all depressed fractures ; the strictest aseptic precautions being observed. If this is not done, in a certain percentage of cases, although there are no symptoms dependent upon the depressed bone at the tim of the injury, they are liable to develop later in the form o focal (or Jacksonian) epilepsy.

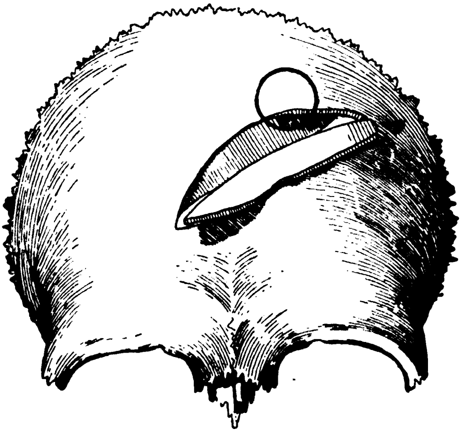

FIG. 328.—Trephining. Depressed fracture of the skull in frontal region, showing place where a trephine should be applied.

In children the bones of the skull are more elastic, and ten readily to resume their original position after a depression hence many such cases may safely be treated on the expectan plan without operation, if there are no symptoms due to th depressed bone or to cerebral hæmorrhage or abscess.

Position.—The patient is placed in the dorsal position, th head turned to the sound side, and placed upon the cranial res or supported by one or two sandbags. The surgeon stands o the affected side of the head, and his assistant opposite to him.

Operation.—If the patient is unconscious as the result of th injury, an anæsthetic is not necessary. If, however, one is required, chloroform is the best.

An incision, semilunar in shape if possible, is made, which divides everything down to the bone. A flap is turned downwards with the periosteal elevator, or, if muscle has to be detached, as when the injury involves the temporal fossa, with the scalpel. The flap should be large enough fully to expose the fracture and the adjacent portion of sound bone, the convexity of the flap being towards the vertex of the skull.

The extent and nature of the fracture are now ascertained. If there has been much splintering of bone, it is often possible to elevate or remove the depressed pieces with dressing forceps. If this cannot be done a crown of bone must be removed with the trephine, which will allow the elevation of the depressed fragments. A point is selected near one margin of the depressed portion, and the trephine, with the pin protruding, is placed upon it in such a manner that the pin rests upon sound bone. If it is thought that there has been much splintering, and that a sharp fragment has been driven into the brain, the entire circles of the trephine must rest upon sound bone. The area to be trephined having been determined, a crown of bone is removed in the usual manner. The elevator can now be inserted underneath the depressed portion, and elevation accomplished. The margin of the trephine aperture on the sound bone is used as a fulcrum in lifting up the depressed part.

If hæmorrhage is taking place from the bottom of the wound, after the circle of bone has been removed, it may come from a branch of one of the meningeal arteries, usually the middle, from one of the sinuses, or, if the dura mater has been punctured, from the surface of the brain. In each case the site of bleeding must be ascertained, and a ligature applied to the bleeding point, or the wound packed with a strip of gauze.

When all hæmorrhage has been arrested, any tear in the dura mater is closed by the introduction of sutures. Next, the fragments of bone are replaced as far as possible in their original position, if they are not contaminated with dirt, care being taken not to allow any sharp edge to project towards the meninges. The margins of the incision in the scalp are brought together and fixed in apposition by sutures. One angle of the wound is left open, and a drain of gauze passed down to the region of the fractured bone. Dressings are lightly applied, and fixed in position by strapping and a bandage.

After-treatment.—In favourable cases the fragments will unite, and the external wound will heal by first intention.

Should suppuration occur, free drainage must be maintained, and fomentations applied.

If a large gap is left in the cranial wall, owing to non-union of the fragments, it may be necessary to provide the patient with a metal plate, which shall accurately cover the aperture in the bony skull, and help to protect it from injury. This is carried out at a subsequent date. The metal plate is usually placed external to the skin, but in some cases it has been placed directly upon the bone. The former is the better plan.

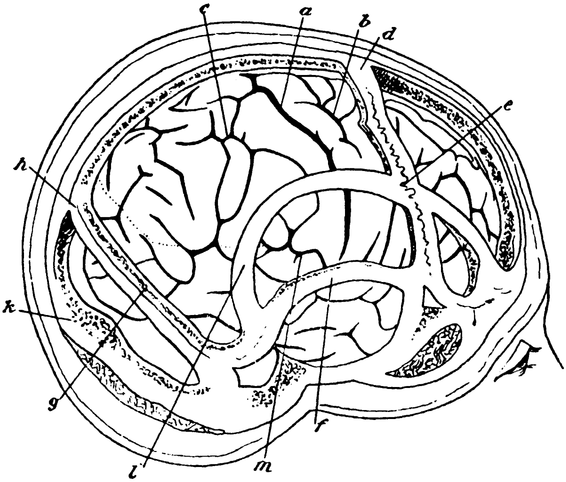

FIG. 329.—The head of an adult female, in which the brain is exposed *in situ*. Bars of bone are left along the lines of the cranial sutures, and also along the line of the temporal ridge.—CUNNINGHAM.

a. Central sulcus of Rolando.
b. Pre-central sulcus.
c. Post-central sulcus.
d. Bregma.
e. Coronal suture.
f. Parieto-temporal suture.
g. Lambdoid suture.
h. Lambda.
k. External occipital protuberance.
l. Superior temporal crest.
m. Transverse fissure (Sylvian) of the brain, posterior ramus.

For extra-dural abscess or hæmorrhage.—*Abscess.*—The formation of an extra-dural abscess is usually preceded by an injury to the cranial bones overlying the seat of the abscess, the injured bone having become the seat of suppuration which has extended through it to the dura mater, owing to the development of a septic osteitis or osteomyelitis. An extra-dural abscess may also develop as the result of general pyæmia, but more commonly it is a precursor of this condition.

When an extra-dural abscess has formed it usually causes the appearance of symptoms of hemiplegia, but often this condition is not well marked, or is marked by symptoms dependent upon general pyæmia. In every case, however, in which the presence of pus between the bone and dura mater is suspected, or in which the bone is the seat of a septic, infective, or suppurative process, trephining ought at once to be performed, and the diseased bone and the collection of pus removed. Stringent antiseptic treatment is then carried out, with the object of preventing further extension of the suppurative process and the elimination of the diseased tissues.

The actual operation in this case is similar to that described above. Free drainage must be established, and frequent irrigation ordered.

Hæmorrhage.—The operative treatment of this condition is fully considered on page 522 in connection with ligature of the middle meningeal artery.

For cerebral tumour or cyst.—The operations for the removal of tumours or cysts of the cerebrum are essentially similar, and will be considered together. An investigation of the nature of tumours which affect the brain has shown, from an analysis of a hundred cases, that forty-five were tuberculous, twenty-four gliomata, two glio-sarcomata, ten sarcomata, five carcinomata, one lymphoma, one myxoma, four cysts, five gummata, and three doubtful.

Indications.—(*a*) The presence of a tumour of the cerebrum, which is primary in nature, and is not associated with secondary growths elsewhere. In the case of tuberculous tumours the absence of general tuberculosis must be established before an operation is undertaken. In the case of a gumma, prolonged treatment with potassium iodide must be tried before an operation is performed.

(*b*) The presence of a cyst of the cerebrum, or of the arachnoid, which is pressing upon the brain and causing symptoms.

(*c*) The presence of a tumour of the dura mater, or of a cranial bone which has extended inwards and is causing symptoms of irritation, etc., owing to pressure upon the brain matter.

Localisation of tumour or cyst. — Before commencing an operation upon the cerebrum for the removal of a tumour or cyst, its position within the cranial cavity, or at least the portion of brain which is being pressed upon, is determined from a consideration of the symptoms which have a localising significance.

Operation.—A large semicircular flap of the scalp is turned down in the usual manner, so as to expose the bone overlying the affected portion of the brain. With the trephine, two or more crowns of bone are removed, the intervening bridge of osseous tissue cut through with the chisel, and the dura mater fully exposed. If the growth has arisen from the internal aspect of one of the cranial bones it will be discovered at this stage and can be removed. When the underlying portion of the dura mater or the brain has been involved in a growth from the internal surface of a cranial bone, the infiltrated portions are removed, provided that they are not too extensive. If the bone or the exposed part of the dura mater is not the seat of origin of the tumour, the dura mater is divided in the usual manner, so as to expose the surface of the brain covered by the arachnoid and pia mater. If the growth has risen from the deep aspect of the dura mater, it is now visible and can be extirpated; or if there is a cyst in the arachnoid, or in the superficial portion of the exposed part of the brain, it can be dissected out and removed.

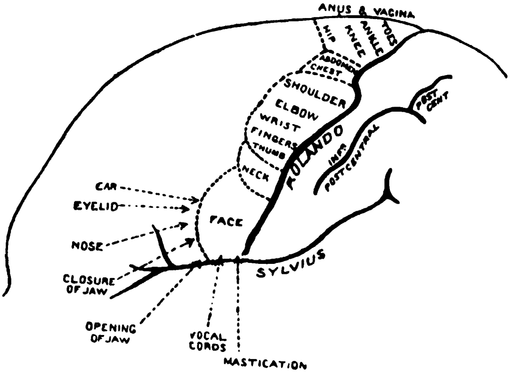

FIG. 330.—Relative topography of the chief subdivisions of the motor area.—CUNNINGHAM.

When a tumour of the cerebrum is being dealt with, the arachnoid and the pia mater are incised, and the limits of the tumour defined. In some cases the cortex of the brain will require to be incised before the tumour becomes visible. Usually, however, its location will be manifest before making an incision of this kind. When the locality and extent of the tumour have been determined, the brain substance is incised with a sharp scalpel all round the tumour, at right angles to the surface. By this means the tumour is freed except on its deep aspect; it is lifted up, and its deep connections with the brain cut through. It can now be removed. Hæmorrhage may take place at this stage, but usually it can be readily arrested by packing the wound with strips of dry gauze and applying slight pressure.

In many cases it will be found advisable to defer the removal of the cyst or tumour until several days after it has been exposed. When the membranes have been incised the flap of superficial structures is replaced and sutured. Dressings are applied, and the patient sent back to bed. After three or four days the membranes will have become adherent to the margins of the incision, and then removal of the tumour is effected as above.

After the removal of the tumour or cyst, and the arrest of all hæmorrhage, the margins of the incisions in the dura mater are united by sutures, and the external wound closed.

Sarcomatous growths which arise in or involve the cerebrum are very prone to recurrence, but even in these cases some improvement of the patient's condition may be effected, and life be prolonged by the operation.

In the case of non-malignant tumours or of cysts the prognosis is much more hopeful.

For cerebral abscess.—An abscess may involve any portion of the cerebrum, and its locality depends upon the pathological condition which has caused it. Thus, in abscess of the brain, dependent upon middle ear disease, it is usually located either in the posterior portion of the temporo-sphenoidal lobe, or in the anterior and external portion of the lateral lobe of the cerebellum of the corresponding side. When the abscess is due to an injury, such as a perforating wound, it is situated in the injured area, whilst if it is due to pyæmia it may be located in any portion of the brain. In the latter case, multiple abscesses are often met with.

Indications.—(*a*) *Abscess of the cerebrum, dependent upon a suppurative affection of the middle ear.*—This is usually located in the lower and posterior part of the temporo-sphenoidal lobe of the affected side.

(*b*) *Abscess of the brain due to an injury.*—If the injury is a perforating one, or the abscess has formed around a foreign body within the brain, the nature of the injury and its point of application will help to determine the locality of the pus. When the abscess is developed in connection with a foreign body, such as a bullet, X-ray photography will help to define the position. In these cases a photograph must be taken in both the antero-posterior and the transverse direction.

(*c*) *Pyæmic abscess of the cerebrum.*—If there is reason to think that a pyæmic abscess of the brain is single, and there are no pyæmic abscesses elsewhere, it is advisable to operate. If, however, an abscess of the brain is only one of the number of pyæmic abscesses, it is scarcely advisable to perform an operation, as good results cannot be expected to follow. Each case of pyæmic abscess of the brain must, however, be considered on its merits, and no general rules can be given as to operation.

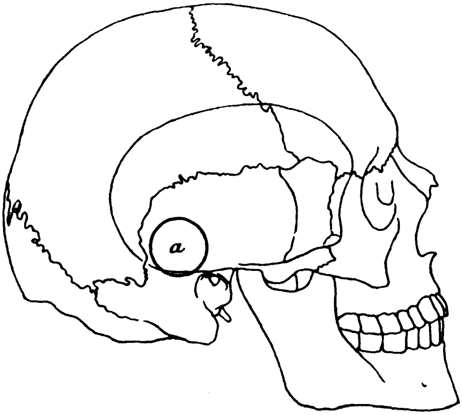

FIG. 331.—Cerebral abscess. *a*. Point for applying trephine in abscess of temporo-sphenoidal lobes.

Operation.—*For an abscess of the temporo-sphenoidal lobe.*

An abscess of the temporo-sphenoidal lobe, when it is due to extension of a suppurative process from the middle ear, is usually situated, in an adult, underneath a point 1 or 1¼ inch above and slightly behind the external auditory meatus.

An incision is made through the scalp in a line corresponding to the free margin of the auricle, and a flap including all the soft structures turned forwards. In the anterior and upper part of the flap a portion of the temporal muscle will be included. The trephine is then applied in such a manner that the pin is upon a point 1 inch above the external auditory meatus, as shown in Fig. 331. A trephine with a diameter of 1 inch should be used. The crown of bone having been removed, the dura mater is incised, care being taken to avoid the posterior branch of the middle meningeal artery, or if it is in the way it should be ligatured before division. The surface of the brain will now be exposed, and often the subdural and subarachnoid spaces will be obliterated in the exposed area by inflammatory adhesions. In cases of suppuration the cervical substance will protrude into the wound, and the position of the abscess can be seen. If it is not visible from the surface, a trocar and cannula should be carefully pushed inwards so as to find the exact situation of the pus. When this has been done a grooved director is passed into the abscess cavity along the side of the trocar, an incision is made through the overlying brain substance, and the pus evacuated, care being taken to protect the margins of the incision with strips of gauze or thin rubber sheeting. The cavity is irrigated with warm saline solution, and a drainage tube passed into the bottom of the cavity and stitched to the inferior angle of the external incision. The remainder of the incision is closed by the insertion of sutures. When there are no adhesions between the dura mater and the affected portion of the brain, it is probably safer, after the pus has been evacuated, carefully to pack the interior of the abscess cavity, for the first few days, with strips of antiseptic gauze, so as to avoid, if possible, the spread of the inflammation to the meninges at the base. If the tube is used in these cases from the first, the pus is liable to escape along its side and gravitate towards the base of the brain.

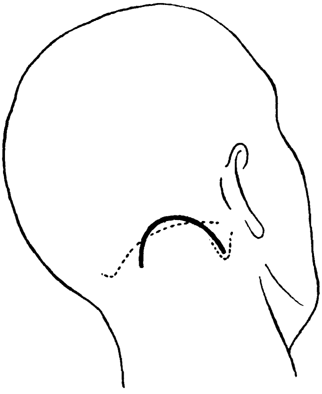

FIG. 332.—Trephining cerebellum. Line of incision in operation for abscess or tumour of lateral lobe of cerebellum.

It is not advisable to replace the bone in cases of this kind.

When the locality of the pus is not exposed by the removal of the first trephine crown, a second one should be taken out, or the original opening enlarged with a chisel or with gouge forceps.

For cerebellar tumour or cyst.—The diagnosis of tumour or cyst of the cerebellum is difficult, owing to the uncertainty of the symptoms which are produced by growths in this situation. When, however, it is possible to make a diagnosis, with a reasonable amount of certainty, that a tumour or cyst of the cerebellum is present and is confined to one side, an attempt should be made to remove it by operation.

Position.—The patient is placed in the semi-prone position, and lying upon the sound side. The neck is supported by a sandbag. The operator stands behind the patient, and his assistant opposite.

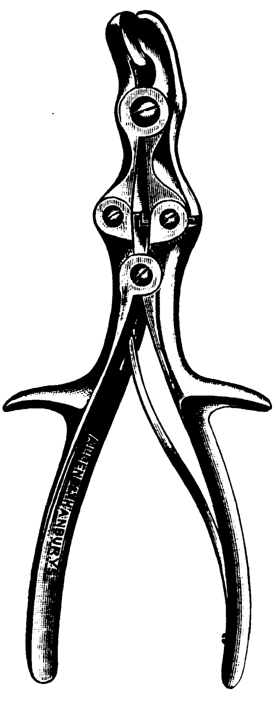

FIG. 333.—Bone-cutting forceps.

Operation.—An incision, semicircular in shape, is made, commencing at the posterior aspect of the apex of the mastoid process, and extending upwards to the base of the mastoid, and then along the superior curved line of the occipital for two-thirds of the distance towards the external occipital protuberance (Fig. 332). This incision is extended down to the bone. In the first part the cut fibres of the sterno-mastoid will be divided, and internally the occipital artery must either be pulled aside or ligatured and divided. It will be found crossing the superior curved line of the occipital bone at the medial part of the incision. With the scalpel and periosteal elevator a flap is turned downwards so as to expose the posterior aspect of the base of the mastoid, and that portion of the occipital bone which lies below the superior curved line. Care must be taken not to separate the soft structures too far inwards, otherwise the spinal canal may be opened, and the medulla oblongata injured between the occipital bone and the atlas. When a sufficient area of bone has been exposed a trephine is applied and a circle of bone removed. In doing this, care must be taken to place the trephine below the line of the transverse sinus. The bone in this region is often very thin, in which case it can be readily removed with cutting bone forceps. When the bone has been removed the dura mater is opened by making a semilunar incision in it with the base towards the transverse sinus. The cerebellum is now exposed, and the tumour or cyst sought for, after the manner mentioned in connection with tumours of the cerebrum.

The further treatment is similar to that recommended in connection with cerebral tumours and cysts.

For cerebellar abscess.—Cerebellar abscess occurs in the majority of cases as a complication of mastoid disease. It may occur, however, in the course of pyæmia, or as a result of an injury. Whenever its existence can be diagnosed an operation is indicated, unless general pyæmia is present and there is no hope of good results following operative interference.

Operation.—An abscess of the cerebellum usually involves the anterior and external portion of one lateral lobe.

An incision is made similar to that described in the preceding paragraph, and the abscess exposed. Evacuation and drainage is established as in an abscess of the temporo-sphenoidal lobe of the cerebrum (*q.v.*, p. 482).

Tapping and drainage of the lateral ventricle.—This operation has been performed for hydrocephalus, but as yet with very poor results.

Operation.—The side of the skull upon which it is proposed to operate having been decided, an aperture is made in the skull 1¼ inch above and slightly behind the external auditory meatus, as in trephining for temporo-sphenoidal abscess (Fig. 331). When the dura mater has been turned aside a trocar is pushed inwards towards a point 2½ inches above the external auditory meatus of the opposite side. After pushing the trocar or needle through a variable thickness of brain matter, diminished resistance is experienced to the passage of the trocar, and fluid escapes. The fluid is allowed to escape slowly. If it is wished to drain the ventricle a tube is passed inwards, and fixed in position by stitching it to the margins of the parietal wound.

For the removal of foreign bodies within the skull.—In the treatment of compound depressed or punctured fractures of the skull it is often necessary to seek for and remove foreign bodies.

In these cases the trephine is applied in the region of the fracture, and an attempt made to trace the course of the bullet or other foreign body from its aperture of entrance.

It occasionally happens, however, that a bullet becomes embedded either in the brain or the membranes, and gives rise to no localising symptoms. In these cases, if it is thought necessary to attempt the extraction of the bullet or foreign body, it should be localised by X-rays.

In the first class of cases a light bullet-probe is passed along the wound, the instrument being allowed to find its way more by its own weight than by pressure exerted by the surgeon. If a hard substance is felt, bullet forceps are passed along the probe, and an attempt made to extract the foreign body.

When the missile has passed through the brain, and is located on the opposite side of the skull to the fracture, it is advisable to make a second trephine opening over the foreign body, and remove it through this. Such a method of treatment, especially in the case of irregular and angular bodies, entails less injury to the brain substance than when it is removed with long forceps through the aperture of entrance.

When the position of a bullet or foreign body has been located within the cranium by the aid of two X-ray photographs, one taken in an antero-posterior and the other in a transverse direction, it is marked out on the surface of the scalp with an aniline pencil. Next, a semilunar flap of the scalp is turned down in the usual manner, and the bone removed with a trephine. The dura mater is incised if necessary, and the brain substance as well, when the bullet is underneath the cortex, and by this means the foreign body is laid bare. It is seized by forceps of appropriate shape, and removed. All hæmorrhage from the brain tissue is arrested, the incision in the dura mater is sewn up, the fragments of bone are replaced in their original position, and the scalp wound closed by a series of interrupted sutures.

When the bullet or foreign body has given rise to suppuration, the cavity is treated according to the method described in connection with cerebral abscess.

Operative treatment of Jacksonian or focal epilepsy.—*Indications.*—Whenever the fits of epilepsy repeatedly commence by movements in a small and definite group of muscles, it is justifiable to expose that portion of the cortex of the brain in which the cortical centres for these muscles are located. If a tumour of the bone or meninges, or a cyst or tumour of the cerebrum, is found, it is removed, according to one of the methods previously described.

If, however, the exposed part of the cortex of the brain is apparently healthy, and no tumour can be discovered in the subcortical tissue, it does not appear to be justifiable to remove a wedge-shaped portion of brain tissue which shall include the cortical motor centres of the affected group of muscles. If this is done, the corresponding muscles become paralysed and the limb useless. Moreover, the scar which results from the removal of a portion of the brain will usually contract and affect the adjacent motor centres.

Temporary resection of the skull.—The term "temporary resection of the skull," or osteoplastic resection, is given to that operation in which a flap of the skull wall is turned back without completely detaching it; and, after an examination has been made of the exposed cranial contents, or an operation has been performed upon them, this flap is replaced in its original position and fixed by the insertion of a few sutures in the scalp.

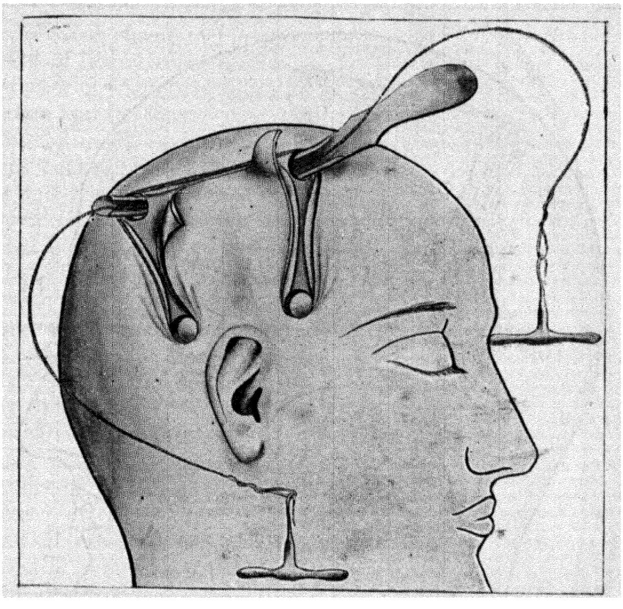

FIG. 334.—Temporary resection of the skull. The flap of soft tissues has been partially turned down, four trephine holes made, and a director and the wire of a Gigli's saw inserted.

Indications.—This operation is indicated in cases in which it is advisable to make an extensive examination of the cranial contents, or on which a large piece of bone must be removed in order to obtain the requisite amount of room for the removal of an intracranial tumour.

After the osteoplastic flap has been turned down and the extent of the disease determined, the condition of the patient may be such that it is advisable to defer the intracranial portion of the operation until a later date (four to eight days later). Consequently it is always necessary carefully to watch the condition of the pulse, etc., and if the patient exhibits signs of severe shock, to replace the flap, fix it with a few sutures, apply dressings, and postpone the completion of the operation until later.

Instruments.—As for trephining, with the addition of a Gigli's wire saw, special large cutting bone forceps (and when preferred, a surgical circular saw driven by an electric or other form of motor).

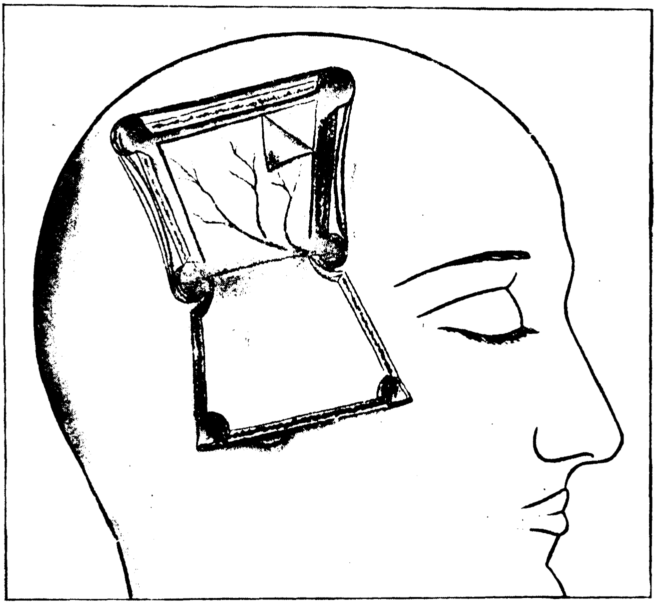

FIG. 335.—Temporary resection of the skull. The osteoplastic flap has been turned down and the meninges exposed.

Position.—The patient is placed in the dorsal position, with the head turned to the side opposite to that on which the operation is to be performed, and the head resting on the special head-rest of the operation table, or supported by short firm sandbags.

Operation.—An incision, ∩ or broadly pyriform in shape, with the attached base below, and if possible in the temporal region, overlying the portion of the brain it is wished to lay bare, is made with the scalpel, all the soft structures of the scalp, including the pericranium, being divided. Next, with a periosteal elevator the pericranium is separated from its attachment to the bone for about one-third of an inch on each side of the incision. Four trephine apertures are now made through the skull—at each lower extremity of the incision, and at each angle of the broad upper portion, in the positions shown in Fig. 334. The crowns of bone having been removed, a director of whalebone or soft copper is taken and the dura mater separated from the inner table of the cranial bones between the upper two openings and the ends allowed to remain protruding. The wire of a Gigli's saw is next passed along the director, and the bone divided from without inwards between the two apertures. The soft copper director must be left in position as the bone is being cut through, otherwise the dura mater and underlying brain may be injured. The bone should be cut through in a sloping manner, so that the divided portions of bone are bevelled at the expense of the outer table. The object of bevelling the bone in this manner is to ensure that the margins of the divided bone remain in exact apposition after the osteoplastic flap has been replaced, and not tend to be pushed inwards by the pressure of a bandage.

A similar proceeding is then carried out on each side, and when these are completed the bone flap will only remain attached by its base in the temporal region. A strong rugine or elevator is next taken, and with it the bony flap is forcibly lifted up, fractured at its base, and turned back (Fig. 335). In old people, or people with thick cranial bones, it will usually be necessary partially to divide with the Gigli

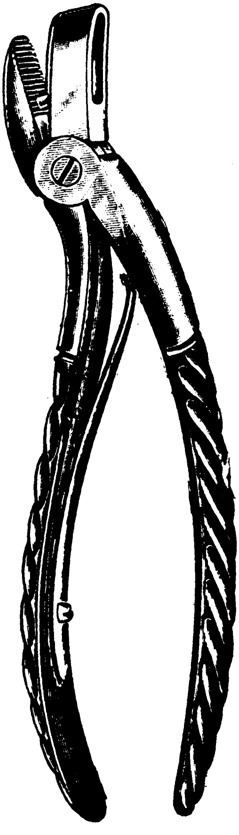

FIG. 336.—Forceps (Keen's) for removing portions of cranial bones.

saw or a chisel the piece of bone in the base of the flap. The dura mater is detached from the internal aspect of the bony flap with a periosteal elevator as the flap is turned down.

The examination of the intracranial contents is now made, the dura mater being divided a little medial to the line of the original incision, if necessary.

When the intracranial examination, or further operation, has been performed (see p. 481 *et seq.*), the margins of the incision in the dura mater are approximated and united with sutures, and the flap of bone and soft tissue of the scalp is turned back into its original position, and fixed by the insertion of sutures. Usually it is advisable to place a rubber drain in the lower and posterior angle of the wound, which is removed at the expiration of twenty-four or thirty-six hours.

If sufficient tissue is not left at the attached part of the bone flap the reflected piece of bone is liable to necrose, especially in people who are no longer young.

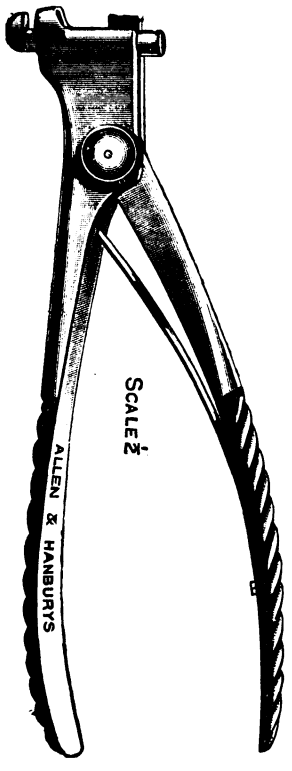

FIG. 337.—Forceps for dividing cranial vault, or enlarging an existing opening.

Craniectomy or linear craniotomy.—The operation of craniectomy has for its object the removal of a portion of the bony cranium.

Indications.—(*a*) Some forms of microcephalus, in which there has been premature union along the lines of the sutures.

(*b*) Cases of closure of the sutures, dependent upon synostosis of the cranial bones, and not necessarily associated with microcephalus, but usually with epilepsy.

A linear piece of the parietal bone, parallel to the sagittal suture and a short distance lateral to it, is generally removed. Portions of the frontal and occipital bones may be removed as well.

Operation.—An incision is made parallel with and slightly lateral to the superior sagittal sinus, commencing at the lambda and terminating at the bregma or a point more anterior ; this divides all the soft tissues of the scalp, including the pericranium. A flap is dissected outwards for a short distance, and then a trephine, ½ inch in diameter, is used to remove a crown of bone. Cutting forceps or Keen's forceps are then taken, and a strip of bone ½ inch in width is removed for the entire length of the incision, from the exposed portion of the parietal bone, and also from the occipital and frontal bones if it is considered to be requisite. This strip of bone may be removed with a Hey's saw. The pericranium is removed along with the bone. Care must be taken not to injure the dura mater, since in cases which

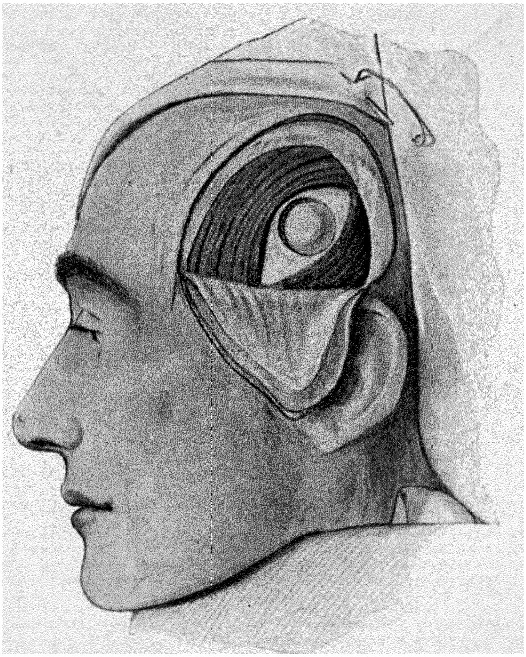

FIG. 338.—Intermusculo-temporal cerebral decompression. (*First Stage.*) The scalp and temporal fascia have been turned down as separate flaps. The temporal muscle is divided in the direction of its fibres, and the exposed bone trephined.—After RAWLING.

require this operation it is usually closely adherent. When the strip of bone has been removed all bleeding is arrested, and the external wound closed by sutures.

Usually it is only necessary to perform the operation upon one side; if, however, the nature of the case necessitates a bilateral operation, a similar portion of bone must be removed from the other side. This is done after the patient has quite recovered from the first operation.

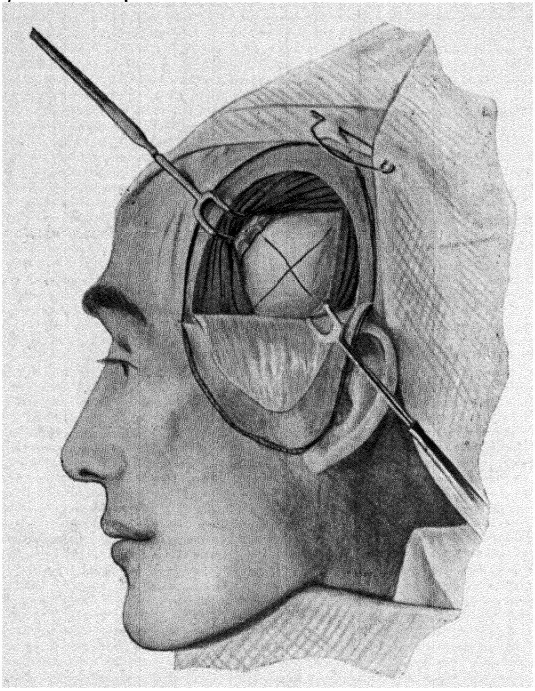

FIG. 339.—Intermusculo-temporal cerebral decompression. (*Second Stage.*) The temporal muscle is retracted on either side, the bone has been freely cut away, and the bulging dura mater incised in a crucial manner.—After RAWLING.

The results which have followed the performance of this operation have as yet not been good. Since, however, the cases are hopeless without operation, it is generally advisable that some surgical measure such as the above should be attempted.

Decompression of the brain.—Patients suffering from intracranial tumours either of the cerebrum or of the cerebellum, in whom the tumour is so situated or is so large that removal of the neoplasm either is not possible or is associated with too serious risks, can often have their condition materially improved and the symptoms of persistent vomiting attacks of intracranial pain and interference with sight lessened by removal of a portion of the cranial vault. The object of this operation is to diminish the intracranial pressure. The operation has been called " decompression," and can be carried out in the temporal, occipital, or parietal regions. Usually for tumours of the cerebrum or of the base the temporal region is the site selected, and for those of the cerebellum the area below the superior curved line of the occipital bone is the more convenient. I have also successfully used the parietal region as the site for this operation. The advantage of the

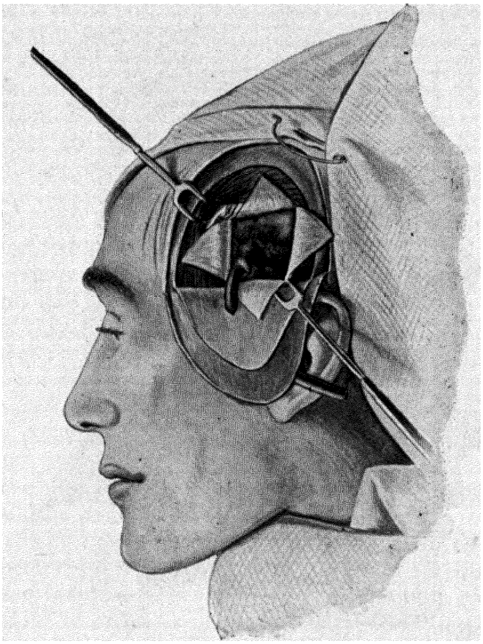

FIG. 340.—Intermusculo-temporal cerebral decompression. (*Third Stage.*) The dural flaps are turned aside, exposing the temporo-sphenoidal lobe. A rubber drainage-tube has been inserted beneath the brain, lying on the floor of the middle fossa of the skull and brought to the surface through the scalp-flap.—After RAWLING.

temporal region is due to the covering of the bone in this region by the thick and firm temporal fascia and the temporal muscle.

The mortality after a "decompression" operation in the occipital region is much greater than after operation in the temporal or parietal regions, apparently owing to disturbance of the basal portion of the brain. On this account its performance is only recommended under exceptional conditions.

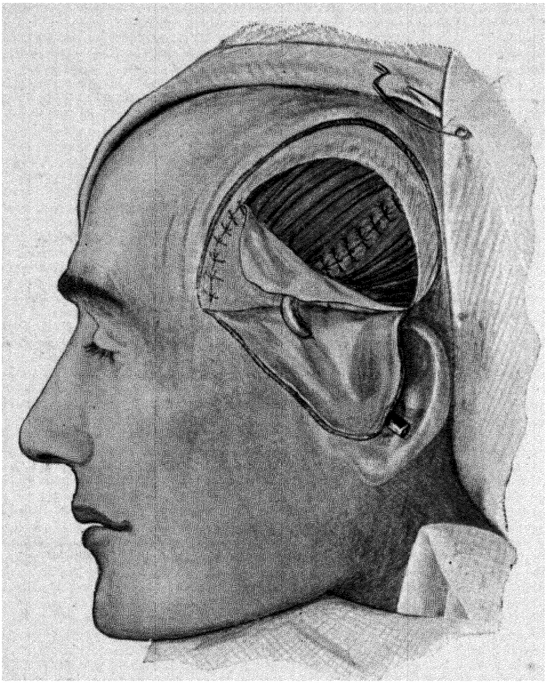

FIG. 341.—Intermusculo-temporal cerebral decompression. (*Fourth Stage.*) The temporal muscle-fibres have been approximated, and the temporal fascia reunited in part. The drainage tube is seen to emerge through fascia and scalp.—After RAWLING.

Operation.—A flap, semilunar in shape, is made by dividing the skin and fascia along the temporal crest commencing in front at a point a little below and behind the lateral angular process of the frontal bone and terminating posteriorly at the root of the zygoma. The skin and subcutaneous tissues are dissected downwards to the level of the zygomatic arch and the temporal fascia laid bare. This latter fascia is then divided in a semicircular direction just below the temporal crest to the level of the zygoma. Next, the fibres of the temporal muscle are separated in a line from the centre of the temporal crest to the middle of the zygoma down to the periosteum, which is also cut through. The margins of the wound in the temporal muscle are strongly retracted, and the periosteum separated forwards and backwards with a periosteal elevator or rugine until a considerable area of the bone forming the floor of the temporal fossa is exposed. A trephine is then taken and a circle of bone removed from the centre of the exposed area. The opening thus made is then enlarged with bone forceps until it is considered that a sufficiently large aperture has been made. An incision, cruciform in shape, is then made with the scalpel in the exposed dura mater, care being taken to avoid any large meningeal blood vessels, and to ligature all small ones which may be cut through. All hæmorrhage having been arrested, the retracted margins of the wound in the temporal muscle and fascia are united by sutures of chromicised catgut. The superficial flap of skin and subcutaneous tissues is then replaced and fixed by the insertion of a row of interrupted sutures. In some cases where there is an excess of cerebro-spinal fluid, a small drainage tube of red rubber is passed down to the cruciform opening in the dura mater, and brought out through a small opening made in the base of the flap a little above the level of the zygoma. This tube should be removed after two or three days.

When the parietal or occipital regions are selected as the site of a " decompression " operation, the procedure is similar to that already described, care being taken that the base of the flap is placed below, in order to ensure the best blood supply.

CHAPTER XXII

OPERATIONS UPON THE SPINAL COLUMN AND SPINAL CORD

LAMINECTOMY.

OPERATIONS FOR SPINA BIFIDA—
  1. By injection.
  2. By excision.

OPERATION FOR CARIES OF THE BODIES OF THE VERTEBRÆ.

LUMBAR PUNCTURE.

BONE-GRAFTING THE SPINE (ALBEE'S OPERATION).

Laminectomy.—Laminectomy is an operation which has for its object the division of the laminæ of one or more vertebræ.

Indications.—(*a*) Some cases of caries of the spinal column, accompanied by the formation of inflammatory products which cause pressure upon the spinal cord.

(*b*) Fractures of the spinal column in which a piece of bone presses upon the spinal cord or causes intraspinal hæmorrhage.

(*c*) Intraspinal tumours or cysts which are thought to be capable of removal.

(*d*) Foreign bodies, such as bullets or pieces of broken knives, within the spinal canal.

(*e*) In operations for exposure and division of posterior nerve roots.

Special instruments.—Resection knife, periosteal elevator, Hey's saw, wide retractors, bone forceps, fine-toothed forceps and fine scissors, laminectomy forceps.

Position.—The patient lies in the semiprone position close to one edge of the table, or upon his face in the complete prone position. The surgeon stands behind the patient, close to the region of the spine upon which he is going to operate, or upon one side when the patient is lying prone. His assistant stands opposite to him.

Operation.—The region of the spinal column upon which it is proposed to operate having been decided, a vertical incision

4 inches in length is made in the middle line of the back, the centre of the incision being opposite the centre of the affected portion of the spine (Fig. 343). With the resection knife the sacro-spinalis (erector spinæ) muscles are separated from the spines and laminæ of the vertebræ, the periosteum being detached along with the muscles as far as possible. By this means the posterior aspect of the vertebræ is exposed. A special form of bone forceps (Fig. 344) is now taken, and the smaller blade passed beneath one of the laminæ of the lowest vertebra upon which it is proposed to operate, and the lamina divided close to its junction with the transverse process. The laminæ may be partially sawn through with a Hey's or other saw before division. This procedure is repeated upon the opposite side. The ligamenta flava which fix the lower borders of the partially separated laminæ to the vertebra below are divided with the scalpel, and then the united laminæ and spinous processes are raised upwards. The laminæ of the vertebra above are divided in a similar manner, and lifted up along with the first. By this means a bony and ligamentous flap, consisting of the laminæ and intervening ligaments of two vertebræ, is partially separated and lifted upwards, and the interior of the spinal column opened.

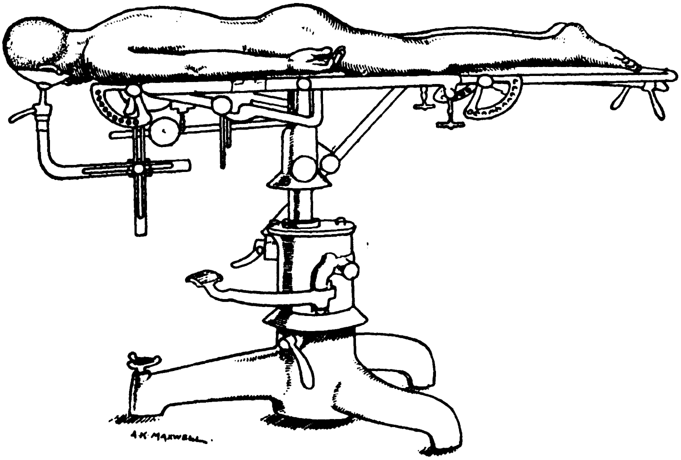

FIG. 342.—Position of patient for operations upon the spinal column, etc.

Any tumour or cyst, projecting spicule of bone, sequestrum, or collection of tuberculous material or blood, can now be dealt with. If more space be required the laminæ of one or more additional vertebræ may be divided.

If it be necessary to expose the spinal cord, the intraspinal veins and fatty tissue are pulled aside and the dorsal aspect of the dura mater exposed. A vertical incision is made through this in the middle line, either with the scalpel or with fine scissors and toothed forceps. The margins of this incision are held apart, and the spinal cord, together with the region of the spinal nerves, laid bare. If hæmorrhage has taken place within the dura mater the blood is removed.

When it has been found necessary to open the dura mater, the incision is afterwards closed with a series of fine silk sutures.

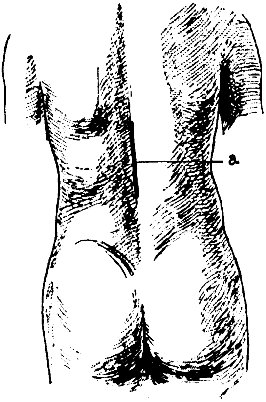

FIG. 343.—Laminectomy. *a.* Position of incision for lower dorsal region.

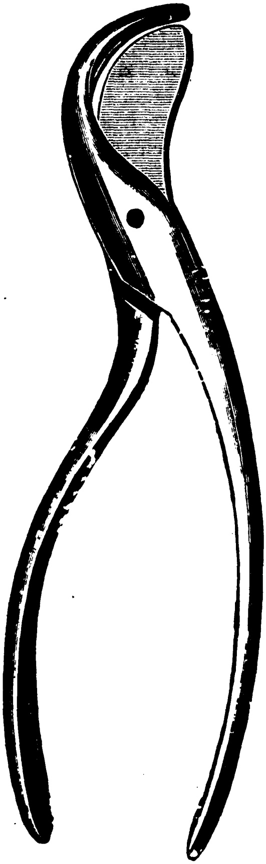

FIG. 344.—Laminectomy forceps.

In those cases in which the operation has been done for fracture of the spinal column, intraspinal hæmorrhage, resection of posterior nerve roots, or tumour, the bony and ligamentous flap is replaced and the wound closed by the insertion of sutures.

In inflammatory cases the laminæ are usually entirely removed: the upper part of the wound is closed with sutures, and the lower part left open for drainage.

Operation for spina bifida.—*Indications.*—Those cases of spina bifida which do not tend to undergo spontaneous cure, and in which a fatal result is to be apprehended in the absence of surgical treatment.

Operation.—Two methods of treatment have been made use of, one of which consists in the injection of an irritant fluid into the sac, and the other incomplete removal of the sac.

(*a*) *Injection.*—The fluid which is generally used for this purpose consists of a mixture of iodine, iodide of potassium, and glycerin, in the following proportions:—Iodine, 10 grs.; potassium iodide, 30 grs.; glycerin, 1 oz. (Morton's fluid).

Injection should be limited to those cases in which the spinal cord does not occupy the interior of the sac.

A long fine needle, to which is attached a small syringe, is pushed into the base of the tumour, care being taken that it passes through sound tissue. The fluid is withdrawn from the interior of the swelling and then 1 or 2 drms. of the injection fluid are introduced.

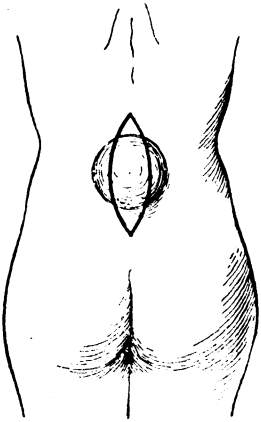

FIG. 345.—Spina bifida. Operation for radical cure. Line of incision through skin over lateral margins of tumour.

This operation generally has to be repeated several times in order to effect a cure.

(*b*) *Excision.*—An oval-shaped incision is made around the base of the tumour (Fig. 345), and the sac dissected from the surrounding tissues until the margins of the deficiency in the wall of the spinal canal have been reached. The sac is now opened, the contained fluid allowed to escape, and any nervous structures which may happen to be within the sac returned, if possible, into the spinal canal. The distal portion of the sac is cut away, and the margins of the aperture which is left carefully approximated by the insertion of numerous fine silk sutures. The sacro-spinalis (erector spinæ) muscles on each side of the opening are separated for a short distance, and then united over the stump of the sac. The operation is completed by closing the skin incision in the usual manner.

Operation for caries of the bodies of the vertebræ.—An operation may be performed for the removal of collections of pus, which are dependent upon caries of the anterior portions of the bodies of the vertebræ in the lumbar and in the dorsal region.

Special instruments.—Large flat retractors, bone forceps, sequestrum forceps, Volkmann's spoon.

Position.—The patient is placed in the semiprone position, lying upon the sound side, with a pillow beneath the loin. The surgeon stands behind the patient, and the assistant opposite to him.

Operation.—A vertical incision 3 inches in length is made in the lumbar region, over the lateral part of the sacro-spinalis muscle, commencing above a short distance below the lower border of the last rib. The skin, fascia, and sheath of the sacro-spinalis muscle are cut through and the vertical fibres of the muscle laid bare. This muscle is strongly drawn medially in order to expose the middle layer of the lumbar aponeurosis, which forms the anterior portion of its sheath. With the left forefinger the surgeon feels for the apices of the transverse processes of the lumbar vertebræ in the floor and inner part of the wound. When these bony prominences can be felt, a vertical incision is made through the anterior layer of the sheath of the sacro-spinalis immediately lateral to these processes. The lamina of lumbar aponeurosis thus divided is drawn outward so as to lay bare the posterior aspect of the quadratus lumborum muscle, the fibres of which run in a slightly oblique direction. The fibres of this muscle are detached from the transverse processes, care being taken to avoid the lumbar arteries and their branches. These vessels lie in the intervals between the transverse processes. When the quadratus lumborum has been separated it is retracted laterally. The posterior aspect of the sheath of the psoas muscle is now exposed. The muscle is detached from the transverse process of one of the vertebræ, and an aperture made into the abscess cavity. The surgeon's forefinger is then passed along the anterior aspect of one of the transverse processes until the body of the vertebra is reached.

The aperture in the sheath of the psoas muscle can be increased now to any desired extent, and the contents of the abscess cavity removed. The forefinger should examine the interior of the abscess in order to locate the different pouches and pockets and also the presence of pieces of necrosed bone.

The latter are removed with sequestrum forceps, and then the interior of the abscess cavity is irrigated with warm saline solution.

Careful sponging with small sponges on holders will often materially help in removing all flakes of tuberculous material. The cavity is again irrigated, then carefully sponged dry, and the external wound closed by the introduction of sutures. Buried sutures should be used for the closure of the deeper parts of the wound.

After-treatment.—The patient is kept in bed at absolute rest until the parts have healed. Often this entails rest in bed for several months.

Lumbar puncture of the spinal canal.—*Indications.*—The indications for this operation are cases of hydrocephalus, where it is performed in order to effect drainage, or for the purposes of injection of some anæsthetic solution when it is desired to induce spinal anæsthesia, and for purpose of diagnosis in bacterial affections of the membranes of the brain and spinal cord.

Special instruments.—Fine trocar and cannula, and injection apparatus.

Position.—The patient lies in the semiprone position, with the thigh flexed on the abdomen, and the surgeon stands behind him; or he may be seated with the head and shoulders bent forwards, the object in both cases being to separate the lumbar spines and laminæ.

Operation.—The space between the fourth and fifth lumbar vertebræ is selected, and a point determined which lies immediately below the bisection of a line drawn transversely between the highest parts of the iliac crests. With the left index-finger on the fourth lumbar spine the trocar is thrust into the vertebral canal about a quarter of an inch to one side and just below this prominence, the point being directed inwards and upwards.

Should the needle engage bone the direction is inaccurate, and it is best to withdraw it a little and thrust it in through the same skin puncture a little lower, since manipulations of the buried needle give pain, and risk breaking it against the laminæ.

The point of the needle having found the canal, the trocar is withdrawn, when some drops of cerebro-spinal fluid should run from the cannula, and the required measures may then be adopted. In the adult the end of the spinal cord is situate opposite the lower border of the first lumbar vertebra, and in the child opposite the lower border of the second.

The average distance from the surface is a little more than 1 inch.

Bone-grafting the spine (Albee's operation).—*Indications.*—In active tuberculous disease of the spine, in fracture dislocation of the spine, and in the early stages of spondylitis deformans when accompanied by much pain.

Special instruments.—Albee's motor saw, Albee's broad and narrow osteotomes, mallet, chisel, flexible probe, callipers, bone forceps, bone drill, kangaroo tendon.

Position.—The patient is placed upon the operation table in the prone position, the back and the region of the leg from which the graft is to be taken having been sterilised.

Operation.—The operation can be divided into three stages—(*a*) The incision over the spine, and preparation of the bed for the graft; (*b*) the incision over the tibia, and preparation of the graft; (*c*) the fixation of the graft in position, and closure of the wounds.

(*a*) *Incision over spine, and preparation of the bed for the graft.*—A long, slightly curved incision is made, starting at least three vertebræ above the diseased portion of the spine and finishing an equal distance below, the incision passing to one side of the mid-line and dividing skin, superficial and deep fasciæ. A flap is turned back exposing the spines of the vertebræ and the supra-spinous ligaments incised throughout the extent of the wound. With a broad, thin, sharp osteotome (Albee's 1½ inch), the spinous processes are split for about ½ inch: one-half of each spinous process, always on the same side, is fractured completely at its base and set over a distance varying according to the thickness of the graft which is to be implanted. Two or three spinous processes, both above and below the diseased vertebræ, should be included in the graft bed.

A flexible probe is now taken and moulded into the shape of the graft bed. The graft bed is now packed with gauze soaked in hot saline.

(*b*) *Incision over the tibia, and preparation of the graft.*—With the patient remaining prone, the prepared leg is fully flexed on the thigh, and by a long curved incision the internal surface of the lower three-fourths of the tibia is exposed for a sufficient length to cut the required graft. The incision should be so planned that the subsequent line of suture shall not lie over the groove in the tibia from which the graft has been removed. The muscles are detached from the crest of the tibia, but the periosteum is not disturbed. The shape of the graft is outlined by incising the periosteum with a scalpel, using the moulded probe as a pattern.

If the graft is to be straight, it is best removed from the crest of the tibia ; if curved, the point of maximum convexity should include the crest.

The graft, which should include periosteum, compact bone, and marrow, is next cut along the lines of incision of the periosteum, using an Albee's motor saw, or, if this is not available, a mallet and chisel. The graft is lifted in forceps, and the wound in the tibia packed by an assistant with gauze soaked in saline, and left to a later stage of the operation.

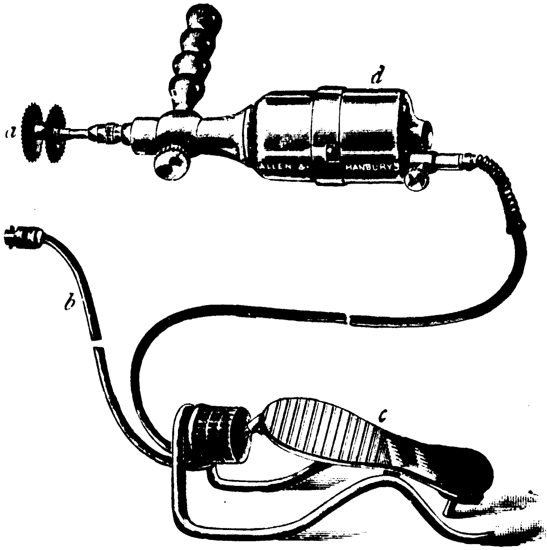

FIG. 346.—Albee's motor saw.

a. Cutting blades.
b. Electric connection.
c. Foot regulator.
d. Electric motor.

(*c*) *Fixation of the graft, and closure of the wounds.*—The graft is transplanted straight away to its new bed. If the graft is straight it will be placed in position with the periosteal surface dorsally, but if the graft be curved it must be placed in the bed edgewise. In this circumstance the periosteum should be in contact with the cut surface of the fractured parts of the spinous processes. Strong sutures of kangaroo tendon are now passed through the two halves of the split supra-spinous ligaments and tied over the graft, thus holding it firmly in position. The first suture should be introduced over the middle of the graft ; then one at either end, and subsequently as many intermediate ones as may be required.

The skin incision is closed with interrupted sutures of fine silkworm gut, and dressing and pads are secured in position with zinc oxide strapping.

The wound in the leg is closed and dressed in the usual manner.

After-treatment.—The patient is kept recumbent in a fracture bed for six weeks, after which time it is not necessary, as a rule, to wear any external support, although in exceptional cases a plaster jacket may be necessary.

It is important to note that this operation does not remove the disease, but only secures perfect immobilisation of the diseased portion of the spine, which is the first essential in treatment.

CHAPTER XXIII

OPERATIONS UPON THE ARTERIES

- LIGATURE OF ARTERIES.
- SUTURE OF ARTERIES.
  - Lateral.
  - End-to-End.
- ANEURYSMORRHAPHY.
- ANEURYSMAL VARIX.

Indications for ligature of arteries.—The following are the most important clinical conditions which may necessitate ligature of an artery :—

- Aneurysm.
- Primary and secondary hæmorrhage.
- Preparatory to the removal of important organs, in order to avoid excessive hæmorrhage.
- Certain cases of pulsating tumours—for example, ligature of the internal carotid for a pulsating tumour of the orbit.
- Certain cases of malignant tumours which have undergone ulceration and are liable to hæmorrhage, or in order to arrest their growth.

The positions of the patient and the operator.—The positions of the patient and the surgeon depend upon the situation of the artery which it is proposed to ligate. The patient is placed in a position which permits the exact demarcation of the blood vessel, and allows of easy access to it ; whilst the surgeon stands, in the majority of instances, at that side of the patient which is to be operated upon, his chief assistant being on the opposite side.

Instruments.—The instruments which are required for the ligature of arteries are—

1. *Knife.*—An ordinary scalpel, not too large, is best for the purpose. Some surgeons advise that the skin incision should be made with a large one, and the deep dissection with a smaller one ; this, however, is not necessary.

2. *Dissecting forceps.*—These should be of medium size, and not too sharp at the points; two pairs are requisite. When a deep artery is being ligatured it may be advisable to have in addition a long pair of forceps with fine serrated points, in order to seize the sheath of the artery while opening it; but this is not usually necessary, as the ordinary dissecting forceps can generally be used for this purpose.

3. *Retractors.*—The kind which is most useful depends upon the artery which is being ligatured. Thus, for the iliac arteries, or whenever there is a deep wound, wide retractors are the best; while, when the vessel is superficial, blunt hooks serve the purpose. In the case of deep wounds it is better to have both blunt hooks and broad and deep retractors.

4. *Pressure forceps.*—These are for the arrest of hæmorrhage from the margins of the wound. Several pairs are requisite. When operating upon large arteries it is advisable to have an elastic tourniquet at hand; this may be found necessary for the control of serious and sudden hæmorrhages.

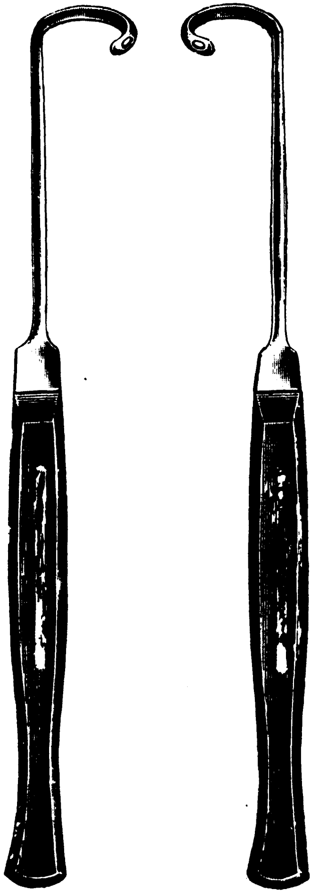

Fig. 347.—Ligature of arteries. Aneurysm needles with a double curve, one to the right and the other to the left.

5. *Aneurysm needle.*—An ordinary curved needle is sufficient in most cases, but for deep-seated arteries, such as the iliacs, a double-curved needle will be most useful (Fig. 347). Two of these should be at hand, one curved to the right and the other to the left.

6. *Ligature and suture material.*—This should be of two thicknesses, one for the vessel itself, and the other for the

ligation of any small vessels which may be cut during the operation, and for sewing up the wound afterwards. Silk is the best ligature material, but many surgeons prefer chromicised cat-gut. For the external wound, salmon-gut will be found the best.

7. *Needles.*—An ordinary medium-sized half-curved or straight needle is used for sewing up the external wound. When it is necessary to introduce a tier of deep sutures a fully curved needle and a needle-holder will be found requisite.

General method of operating.—The operation for the ligature of an artery in its continuity consists of several distinct stages, namely—

(*a*) *Skin incision.*—The anatomical position of the artery is determined according to the directions which are given in the text-books of anatomy. Great care must be taken in placing the patient in the correct attitude, so as to avoid the possibility of a mistake being made. When this has been done an incision is made through the skin, usually in the line of the blood vessel, varying in length according to the size of the artery and its depth from the surface of the body. Thus, in ligature of the radial at the wrist, an incision of 1½ inches is quite sufficient, whilst for the first portion of the axillary artery it must be 4 inches long. As a general rule, it is advisable to make a moderately long incision, since no harm can be done by this, and the dangers of working in a confined space are avoided. In operations on the face or the exposed parts of the extremities, it is better to avoid making too long an incision, on account of the resulting scar being visible. Whilst making the incision through the skin, the knife may be held in either the "dinner-knife" or the "dissecting" position (Figs. 53 and 51). In the case of small incisions it is advisable to adopt the latter method, and for long incisions the former. The blade of the knife should be sloped whilst making the main part of the wound, and, finally, it should be brought out vertically, so as to avoid "tailing," and to ensure that the wound is of equal depth for its entire extent. Care must be taken to avoid damage to any superficial veins

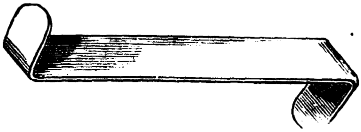

FIG. 348.—Form of retractor suitable for use in exposure of an artery.

when the skin incision is made; but if one of these structures cannot be easily avoided it must be cut through and its two extremities tied.

(*b*) *Division of the deep fascia.*—The deep fascia can, in most parts of the body, be recognised as a thin dense lamina of fibrous tissue immediately underneath the fatty layer. It is divided for the entire extent of the incision, and by this means the muscular strata are exposed. It is important to recognise the deep fascia, especially in fat people or when operating upon the dead body, since all arteries the ligature of which is required lie underneath this layer.

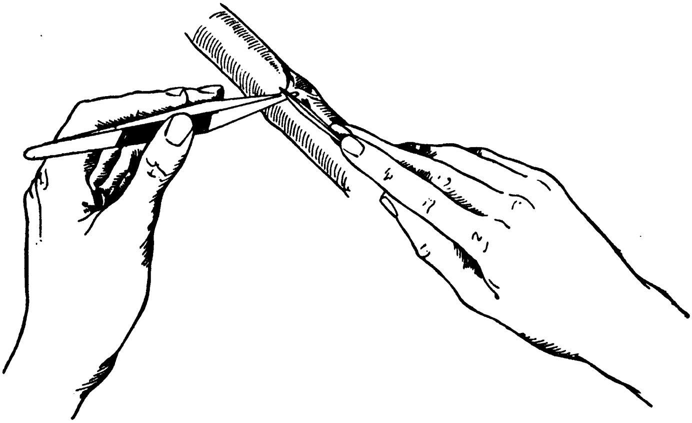

FIG. 349.—Ligature of arteries. Method of opening the sheath of an artery, before an aneurysm needle is passed.

(*c*) *Separation of the muscles or tendons, and exposure of the artery.*—When the deep fascia has been divided its margins are drawn aside and separated with retractors, so as fully to expose the muscular layer. In most cases the space between two particular muscles has to be recognised in order to find the blood vessel. This separation is best effected with the finger, aided by a probe-pointed director, or a blunt dissector. The intermuscular septum between two muscles is said to be indicated by a white line, which is caused by a localised thickening of the fascia, but this sign cannot be depended upon. It is better to trust to the finger, and to feel for a slight depression along the line of separation between the two muscles. The muscles are held apart with retractors, and care is taken to make the wound of the same depth throughout. When the muscles have been separated the artery, usually, can be recognised lying at the bottom of the wound, and often accompanied or surrounded by its venæ comites, or having a nerve in close relation to it. In the living person the artery can be distinguished, usually, by its pulsations, but care must be taken not to mistake a transmitted pulsation for the true pulsation of the vessel itself.

(*d*) *Opening of the sheath of the artery and passage of the needle and ligature.*—When the artery has been exposed its sheath is opened, so as to permit of the easy passage of the ligature, and to avoid the enclosure of or injury to any important adjacent anatomical structure by the ligature. A small fold of the sheath, transverse to the long axis of the artery, is picked up with fine forceps and incised with a scalpel, an aperture about ⅓ inch in length being made in it (Fig. 349). The aperture should lie over the centre of the exposed portion of the vessel or, when there is only one accompanying vein, somewhat to the side farthest away from that structure. Thus, in the case of the common carotid artery, it is advisable to make the incision into the sheath well on the medial side, so as to avoid wounding the jugular vein, which overlaps it to a considerable extent. When the incision into the sheath is being made, the sheath itself should be lifted quite away from the vessel for a distance of about ⅓ inch by means of dissecting forceps. One margin of the incision in the sheath is seized with the forceps, and then the point of the aneurysm needle is gently insinuated round the artery for half its circumference. Next, the other margin of the sheath is seized and the point of the needle passed round in the opposite direction, until the sheath is separated for the entire circumference. When this has been done, the margin of the sheath which lies adjacent to the accompanying vein, or other important anatomical structure, is held with forceps, and the

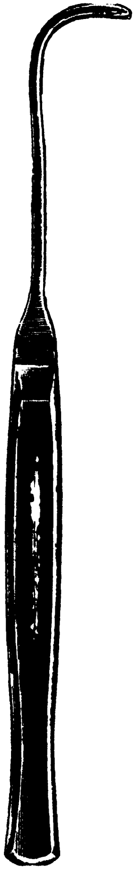

FIG. 350.—Ligature of arteries. Simple curved aneurysm needle.

aneurysm needle passed around the artery, care being taken not to lift up the vessel from its bed more than is absolutely necessary. The aneurysm needle is always passed around an artery in an unthreaded condition, and then threaded with a ligature (usually silk), and withdrawn. If the sheath of the artery has been well opened and separated, and the needle is kept close to the wall of the vessel as it is passed, there is very little risk of doing any injury to neighbouring structures. The ligature is tied with a " reef-knot," at right angles to the long axis of the vessel. The knot is made gradually, and no sudden tension or pull exerted. During the tying of the ligature the artery must not be lifted up in the wound ; this is prevented by making the extremities of the two forefingers meet immediately above the artery upon the side of the knot, and exerting tension from the knuckles. The ligature should be tied tightly enough to rupture the inner coats of the vessel. The ends of the ligature are finally cut short, and the knot allowed to retract into the interior of the sheath.

Some surgeons prefer to tie the artery in two places, and then to divide the vessel between the ligatures. This, in my opinion, is not usually necessary, and in certain regions it is dangerous. This is especially so in connection with the third part of the subclavian.

(*e*) *Closure of the external wound.*—In most cases of ligature of an artery it is not necessary to divide any muscles, and hence, when the retractors are removed, the structures resume their normal position ; but if it is found requisite to divide a muscle or muscles, or if the deeper parts of the wound do not come into good apposition, it is necessary to unite these with a tier of deep sutures. The margins of the incision in the skin and fasciæ are then united by the insertion of interrupted sutures, and the ordinary dressings applied.

Exposure and Ligature of Individual Arteries

The innominate artery.—The innominate artery is a large branch of the thoracic aorta, given off from the convexity of the arch opposite a point situated slightly to the right of the middle of the manubrium sterni. From its origin it passes upwards and to the right to the base of the neck, where it terminates by dividing into the right common carotid and right subclavian arteries.

Its course is represented on the surface of the chest by drawing a line from a point immediately to the right of the central point of the manubrium sterni to the upper border of the sterno-clavicular articulation of the right side. The vessel usually measures about 1½ inches in length, and gives off no branches in its course, though, in exceptional cases, it may give origin to the thyroidea ima.

The innominate artery lies behind the manubrium sterni, the origins of the right sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus gland; whilst at its origin it is crossed by the left innominate vein, and for its entire course it is overlapped from the lateral side by the right innominate vein. To the right lie the right innominate vein, the right vagus nerve, and the parietal layer of the right pleura and the right phrenic nerve; on the left, the inferior thyroid veins, the remains of the thymus gland, and the commencement of the left common carotid artery; behind, it is in relation with the thoracic portion of the trachea and the right pleural sac. The height at which the vessel divides varies; sometimes it is lower than usual, but only rarely does it divide in the neck above the clavicle.

Position.—The patient is placed in the dorsal position, near the right side of the table, the shoulders are raised, the right arm pulled downwards and fixed in that position, the head extended and rotated towards the left.

The surgeon stands facing the right shoulder, the chief assistant opposite to him, and a second assistant on the left side of the head.

Operation.—An angular incision is made, one limb of which extends along the upper border of the medial third of the clavicle, and the other limb along the anterior border of the sterno-mastoid muscle. Each part of the incision is about 3 inches in length. The skin, superficial fascia, and deep cervical fascia are divided along both parts of the incision, and the muscles exposed. The outer and lower portion of the sterno-mastoid and the sterno-hyoid and sterno-thyroid muscles are divided close to their attachments to the clavicle and sternum, and a flap turned upwards and outwards. The deep cervical fascia which lies behind the muscles is now laid bare, and the carotid sheath can be seen in the medial portion of the wound. Care must be taken, when turning up the flap, not to injure the anterior jugular vein as it passes behind the medial part of the sterno-mastoid. The carotid sheath is opened in the lower part of the incision, and the common carotid artery traced downwards and medially until the innominate artery is well exposed. When this has been done it is separated from its sheath as carefully as possible, so as to avoid injury to the veins in the immediate neighbourhood. The right innominate vein may be considerably dilated, and overlap the artery ; the left innominate vein may cross higher than usual, and appear in front of the vessel in the upper part of its course ; and the inferior thyroid veins may be very large and overlap the innominate artery from the inner side. When the artery has been separated from its connections the aneurysm needle is passed from the lateral side, care being taken to avoid puncture of one of the veins, injury to the pleura, or enclosure of the right vagus nerve. A strong silk ligature is probably the best form of material to tie the vessel with. Some surgeons advise that the common carotid and vertebral arteries should be ligatured as well, so as to diminish the risk of secondary hæmorrhage. When this has been done the wound is closed.

When the innominate artery divides at a moderately high level, or when the patient has a long and thin neck, it will be found that the ligature of the vessel can be effected through an incision along the anterior border of the sterno-mastoid.

Collateral circulation :—

(*a*) Intercostal branches of aorta with similar branches from the superior intercostal branch of the subclavian.

(*b*) Internal mammary, by means of its superior epigastric branch, with the inferior (deep) epigastric branch of the external iliac, and by means of its musculo-phrenic branch with the lower five or six intercostal branches of the thoracic aorta.

(*c*) The aortic intercostals of the third to the sixth space with thoracic branches of the axillary artery (long thoracic, pectoral branches of thoraco-acromial and subscapular).

(*d*) The inferior thyroid arteries.

(*e*) Communications between various branches of the external and internal carotid arteries on one side, and similar branches on the opposite side.

The common carotid artery.—This vessel on the right side is given off from the innominate artery, and on the left from the arch of the aorta between the innominate and the left subclavian. The thoracic portion of the left artery is not suitable for the application of a ligature. The course of the vessel in the neck is marked out by drawing a line from the sterno-clavicular joint upwards to a point midway between the angle of the jaw and the apex of the mastoid process when the head is turned slightly towards the opposite side. The vessel divides at the upper border of the thyroid cartilage. It is enclosed within a sheath of the deep cervical fascia, and opposite the cricoid cartilage it is crossed by the anterior belly of the omo-hyoid muscle.

That portion of the vessel which lies above the omo-hyoid is covered only by the deep cervical fascia, the medial border of the sterno-mastoid, the superficial fascia, platysma, and skin ; whilst that below this muscle has in front of it, in addition to the above structures, the sterno-hyoid and sterno-thyroid muscles. Within the sheath of the artery lie the internal jugular vein on the outer side, and the vagus nerve behind and between the two. Each structure lies within a special compartment of the sheath. Occasionally, the descendens cervicis nerve is found in front of the artery within the sheath, but usually it lies outside. The carotid tubercle of the sixth cervical vertebra lies immediately behind the artery. The relative position of the artery to the adjacent structures is shown in Fig. 351.

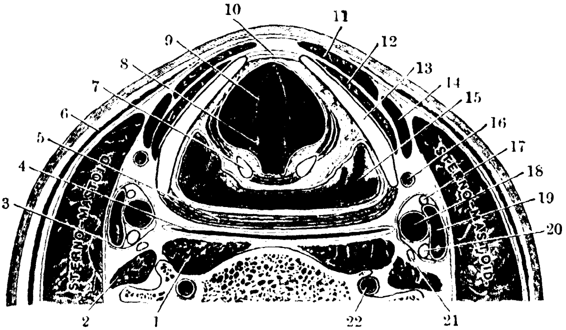

FIG. 351.—Ligature of common carotid artery. Transverse section through the neck at the level of the thyroid cartilage.—CUNNINGHAM.

1. Longus colli.
2. Scalenus anterior.
3. Carotid sheath.
4. Retropharyngeal space.
5. Posterior wall of pharynx.
6. Platysma.
7. Arytenoid cartilage.
8. Processus vocalis.
9. True vocal cord.
10. Thyro-hyoid membrane.
11. Sterno-hyoid.
12. Thyro-hyoid.
13. Thyroid cartilage.
14. Omo-hyoid.
15. Sinus pyriformis.
16. Superior thyroid.
17. Descendens cervicis.
18. Common carotid.
19. Internal jugular.
20. Vagus.
21. Sympathetic cord.
22. Vertebral artery.

A ligature may be applied either above or below the omohyoid muscle, preferably above, in the majority of cases, on account of the superficial situation of the vessel at this level.

Ligature of the common carotid artery above the omohyoid.—*Position.*—The patient is placed in the dorsal position, with the shoulders slightly raised, and the head turned somewhat to the opposite side.

The surgeon stands on the affected side of the patient, and the assistant on the opposite side.

Operation.—An incision is made either in the line of the artery, 3 inches in length, and so situated that its centre is opposite the upper border of the cricoid cartilage, or obliquely across the course of the artery, in the line of cleavage of the skin, and at the level of the cricoid cartilage. The skin, the superficial fascia containing branches of the superficial cervical nerves and possibly tributaries of the external jugular vein, and the deep fascia are divided in the line of the incision. By this means the sterno-mastoid muscle is exposed. The medial border of this is next defined and retracted laterally. The anterior belly of the omo-hyoid will then be seen crossing upwards and inwards. It is pulled downwards with a retractor, and then the carotid sheath will be visible, and lying upon it may be seen in many cases the descendens cervicis nerve. This nerve is pulled laterally and the sheath opened on the medial side, so as to avoid puncture of the jugular vein. The artery is separated from its sheath for a short distance in the usual manner, and the needle is passed from without medially, care being taken not to include the vagus nerve or the sympathetic cord which lies immediately behind the sheath. During the passage of the needle and the separation of the sheath the vessel should not be disturbed more than is necessary. The superior and middle thyroid veins usually cross the front of the carotid sheath, in which case they

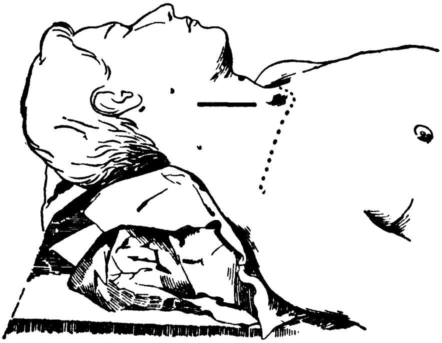

FIG. 352.—Ligature of common carotid artery. Position of patient and line of external incision. Dotted line indicates the clavicle.

are drawn upwards, or ligatured in two places and divided between.

Ligature of the common carotid below the omo-hyoid.—*Position.*—As for ligature of the vessel at a higher level.

Operation.—An incision from 3 to 4 inches long is made either in the line of the artery, commencing, below, a short distance above the sterno-clavicular joint, and extending upwards to the level of the crico-thyroid membrane or the lower portion of the thyroid cartilage (Fig. 352), or obliquely across the course of the artery in the line of cleavage of the skin, and about an inch above the level of the upper border of the clavicle. The skin, the superficial fascia containing the supra-sternal branch of the cervical plexus, and possibly the anterior jugular vein, and the deep fascia, are incised, and the anterior border of the sternal head of the sterno-mastoid laid bare. This muscle is drawn laterally, the attachment to the sternum being divided if requisite, and by this means the sterno-hyoid and sterno-thyroid muscles are exposed, and possibly, in the upper part of the incision, the omo-hyoid. The sterno-hyoid and sterno-thyroid muscles are drawn inwards, their fibres being cut across if necessary, and the omo-hyoid is retracted upwards. One or more inferior thyroid veins may be met with at this stage, and give rise to trouble. If seen they must be drawn medially or ligatured in two places and divided between. The carotid sheath, which contains the artery, is now exposed. The sheath is opened on the medial side, and the needle passed from without inwards. On the left side the internal jugular vein lies somewhat anterior to the artery, and may prove a source of trouble.

Collateral circulation.—(*a*) The superior thyroid with the inferior thyroid ; (*b*) the occipital with the deep cervical and the transverse cervical ; (*c*) the branches of the external carotid, with similar branches from the opposite side ; (*d*) branches of the external carotid with branches of the vertebral ; (*e*) the various communications at the circle of Willis.

The external carotid artery.—This vessel is one of the terminal branches of the common carotid, and is given off at the level of the upper border of the thyroid cartilage. Its course is approximately marked out by prolonging upwards the line of the common carotid. The artery terminates immediately below and internal to the condyle of the lower jaw, by dividing into the internal maxillary and superficial temporal arteries. In its course it gives origin in front and internally to the superior thyroid, the lingual and the external maxillary (facial, O.T.) arteries ; posteriorly it gives off the posterior auricular and occipital arteries, and from its deep aspect the ascending pharyngeal. The superior thyroid is given off immediately above the commencement, the lingual opposite the greater cornu of the hyoid, the occipital and external maxillary at a slightly higher level, and the ascending pharyngeal usually at about the same level. The posterior auricular artery arises a little above the occipital. The superior thyroid may be given off from the common carotid, whilst the lingual and external maxillary not infrequently arise by a common trunk. The artery at its commencement is somewhat superficial, being covered by the skin and fasciæ and overlapped by the sterno-mastoid. The hypoglossal nerve crosses the vessel about 1 inch beyond its origin, and the posterior belly of the digastric muscle at a slightly higher level. The artery is generally ligatured below the digastric at a point between the origins of the superior thyroid and the lingual arteries.

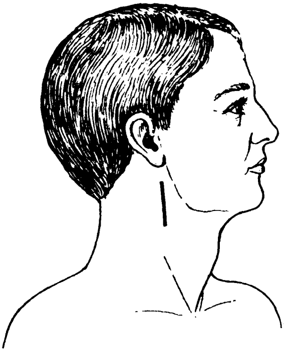

FIG. 353.—Position of incision for ligature of external and internal carotid arteries.

Position.—As for ligature of the common carotid.

Operation.—An incision about 3 inches long is made either in the line of the vessel, the central point of the incision corresponding to the apex of the greater cornu of the hyoid bone (Fig. 353), or obliquely across the course of the artery in the line of cleavage of the skin, and about half an inch below the angle of the jaw. If the greater cornu cannot be felt, the incision extends from opposite the middle of the thyroid cartilage to the angle of the lower jaw. The skin and fasciæ, with the platysma and any superficial veins, are divided and the external surface of the sterno-mastoid exposed. The medial border of this structure is defined, and the muscle drawn laterally. In the upper section of the wound the posterior belly of the digastric muscle is sought for, together with the hypoglossal nerve. When found these structures are retracted to the upper portion of the incision. The apex of the greater cornu of the hyoid bone is next laid bare, together with that portion of the external carotid artery which lies between the points of origin of the superior thyroid and lingual arteries. This part of the vessel may be surrounded by veins, in which case they are drawn aside and the artery separated from the adjacent structures. The aneurysm needle is then passed from without inwards, care being taken to avoid the superior laryngeal nerve, which lies posterior to the vessel. In some cases it is necessary to ligature the exposed part of the external carotid and the separate branches as well, when they are given off in immediate proximity to the point of application of the main ligature.

Collateral circulation.—This is similar to that given in connection with ligature of the common carotid, with the exception of the anastomosis between the superior and the inferior thyroid arteries.

The superior thyroid artery.—The ligature of this artery is carried out through an incision similar to that described for the external carotid. The external carotid is defined and traced downwards until the superior thyroid is exposed.

The lingual artery.—The lingual artery is a branch of the external carotid, given off opposite the apex of the greater cornu of the hyoid bone. Its course may be divided into three parts, —the first extending in an oblique direction from its origin to the outer margin of the hyoglossus; the second is horizontal in direction, and lies underneath the hyoglossus; whilst the third ascends and is situated beneath the tongue.

The first part is superficial, and has the same coverings as the external carotid; the second lies deeper upon the middle constrictor of the pharynx and the genio-glossus and behind the hyoglossus, parallel with the upper border of the great cornu of the hyoid bone, but at a slightly higher level. The cornu of the hyoid bone is the guide to the vessel in this part of its course. The hyoglossus muscle separates the artery from the hypoglossal nerve, which, however, lies at a higher level, and also from the lingual (ranine) vein. The artery may be ligatured in either the first or the second part of its course, usually the latter.

When a ligature is applied to the vessel in the first part of its course, the operation is similar to that for ligature of the external carotid.

Ligature of the lingual artery beneath the hyoglossus.—*Position.*—The patient lies in the dorsal position near the end of the table, with the shoulders raised, the chin turned well upwards and slightly towards the opposite side, and held in position by an assistant.

The surgeon stands on the side which is to be operated upon, the chief assistant on the opposite side, and a second assistant near the operator. The second assistant holds the head in position, and retracts the digastric tendon at the proper time.

Operation.—A curved incision is made, commencing half an inch lateral to and a short distance below the symphysis menti, and extending downwards to the tip of the greater cornu of the hyoid bone, and then upwards to a point a little below and in front of the angle of the lower jaw (Fig. 354). This incision divides the skin, the superficial fascia with the platysma, and the deep fascia for its entire length. When the deep fascia has been fully divided, the lower margin of the submaxillary salivary gland is sought for, and hooked upwards with a retractor. Next, the intermediate tendon of the digastric muscle is exposed, as it lies in the lower portion of the wound. When defined, it is drawn downwards with a blunt hook, and so held by the second assistant. The fibres of the hyoglossus muscle are now visible in the angle between the two bellies of the digastric, and in many cases the hyoglossal nerve of the ranine vein is seen lying upon this muscle. If these latter structures are exposed, they are retracted upwards out of the field of operation, and then with the tip of the finger the upper border of the great cornu of the hyoid bone is felt for. When this has been defined, the fibres of the hyoglossus are cut through about one-third of an inch above the hyoid. A connective tissue or fascial plane will soon be met with when the fibres of the muscle have been divided, and in this tissue will be found the lingual artery (Fig. 355). Care must be taken not to overlook this plane, otherwise the fibres of the middle constrictor may also be divided, and the incision made to communicate with the cavity of the pharynx. Occasionally the lingual artery will be found

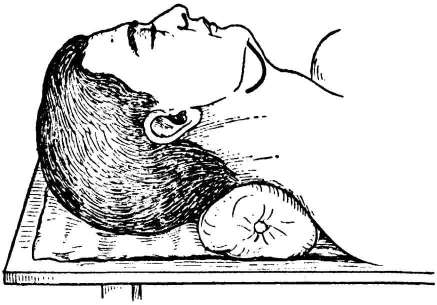

FIG. 354.—Ligature of lingual artery. Position of external incision.

lying a short distance above its usual position, owing to its course being more oblique. When the artery has been exposed it is separated for a short distance from its surroundings, and the needle passed from above downwards.

Ligature of the lingual artery in the first portion of its course, before it passes underneath the hyoglossus, is carried out through an incision similar to that for exposure of the external carotid.

The external maxillary (facial, O.T.) artery.—This vessel is a branch of the external carotid given off a short distance above the apex of the greater cornu of the hyoid bone ; or it may be given off along with the lingual by a common trunk. From its origin the artery passes upwards, lying in a deep groove in the submaxillary gland, and then over the horizontal ramus of the lower jaw, about a third of the distance from the angle to the symphysis, and immediately in front of the masseter muscle. Above this point it passes onwards to the tissues of the face. The vessel can be felt pulsating as it passes over the ramus of the jaw, and also just beyond its point of origin in the neck.

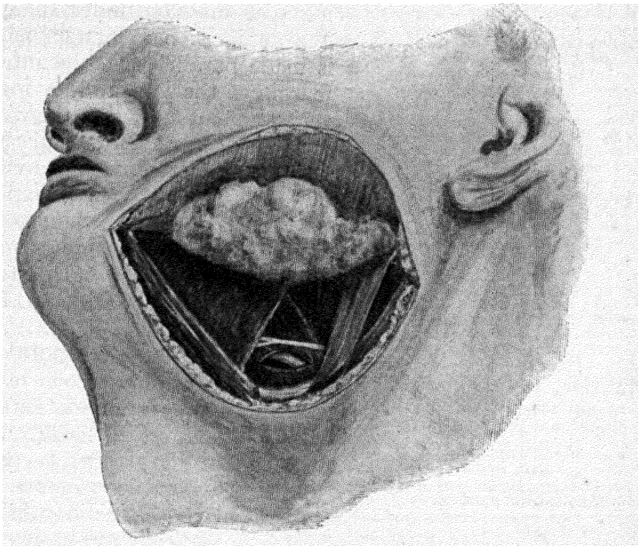

FIG. 355.—Ligature of lingual artery. Dissection showing vessel exposed in bottom of wound.

In the latter position the operation is similar to that for ligature of the external carotid.

Ligature of the external maxillary (facial, O.T.) artery as it lies upon the lower jaw.—*Position.*—The patient is placed in the dorsal position, with the head resting on a pillow and turned over towards the opposite side. The operator stands on the affected side of the head, and the assistant opposite to him.

Operation.—The anterior border of the masseter and the situation of the vessel on the jaw are first defined; then the skin of the neck and face is drawn upwards, so that the resulting scar may be under the jaw, and an incision 1 inch in length is made parallel with the inferior margin of the jaw, and having its central point opposite the vessel (Fig. 356, *a*). The skin, superficial fascia, and platysma are divided, and then the artery will be exposed as it lies upon the bone. The vessel is separated from its accompanying vein, which lies posterior to it, and the needle is passed from behind forwards.

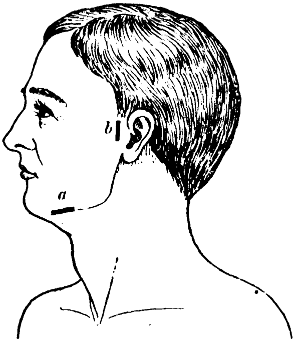

Fig. 356.—Ligature of external maxillary (facial, O.T.) and superficial temporal artery.

a. Position of incision for external maxillary artery.
b. Position of incision for superficial temporal artery.

The superficial temporal artery.—This artery is one of the terminal branches of the external carotid, given off in the substance of the parotid gland. It passes upwards over the zygoma and superficial to the temporo-maxillary joint, to supply the scalp. It may be ligatured where it lies upon the zygomatic arch, in front of the external auditory meatus.

Position.—As for ligature of the external maxillary artery.

Operation.—An incision 1½ inches in length is made along the line of the vessel, a short distance in front of the auditory meatus, the central point of the incision corresponding to the zygomatic arch (Fig. 356, *b*). The skin and fasciæ are divided, when the artery will be exposed lying upon the bone, surrounded by its venæ comites, and having the auriculo-temporal nerve immediately behind it. The vessel is carefully separated from the nerve, and from its veins if possible, and the needle passed from behind.

The occipital artery.—This is a branch of the external carotid, arising from this vessel on its posterior aspect, and a little above the level of the great cornu of the hyoid bone. It first passes upwards and backwards in the neck, and then almost horizontally backwards, between the mastoid process and the lateral mass of the atlas, lying in a groove in the mastoid portion of the temporal bone, and finally ascends vertically to the scalp.

It may be ligatured in the anterior triangle of the neck, or as it lies in relation with the mastoid portion of the temporal bone. In the first case the operation is similar to that for the ligature of the external carotid.

Ligature of the occipital artery as it lies in the mastoid region. — *Position.* — The patient is placed on the sound side, with the head resting on a pillow and turned well towards the opposite side. The surgeon stands on the affected side, and the assistant opposite to him.

Operation. — An incision about 2 inches in length is made, which commences below, at the posterior border of the mastoid process, and immediately above its apex, and extends upwards to a point midway between the posterior border of the base of the mastoid and the external occipital protuberance (Fig. 357). The skin, dense fasciæ, the posterior borders of the sterno-mastoid and the splenius capitis, are divided, and the margins of the wound well retracted. The artery will then be exposed, lying in a groove on the medial aspect of the base of the mastoid process. It is separated from adjacent veins, and the needle passed from either side. Care must be taken not to divide the artery as it lies upon the bone.

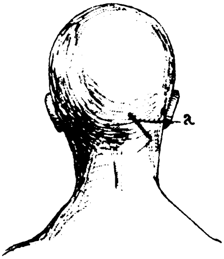

FIG. 357.—Ligature of occipital artery.
a. Position of external incision.

The middle meningeal artery.—The middle meningeal artery is a branch of the internal maxillary, given off in the pterygoid region, and passing into the skull through the foramen spinosum. It lies in a groove in the temporal bone, and is partially embedded in the outer layer of the dura mater. The artery divides into anterior and posterior branches, to either of which a ligature may have to be applied. The anterior branch passes upwards and slightly backwards, and the posterior backwards and upwards, towards the region of the parietal eminence.

Ligature of the anterior branch of the middle meningeal.—*Position.*—The patient is placed in the dorsal position, with the head raised and turned towards the opposite side. The surgeon stands at the affected side of the head, and the assistant immediately opposite to him.

Special instruments.—In addition to the ordinary instruments for the ligature of a blood vessel, those for trephining are also required.

Operation.—The pterion serves for the centre of the field of operation. A point is taken 1½ inches behind the lateral angular process of the orbit, and the same distance above the zygomatic arch (Fig. 358). A flap of the scalp in the form of a semicircle, with a radius of a little more than 1½ inches, is reflected, the incision being made with the convexity towards the vertex of the skull, in order to preserve as far as possible the blood supply of the incised tissues. The scalpel divides everything down to the surface of the bone, except the pericranium, and the flap is reflected. The pericranium is then divided by a crucial incision over the position where the trephine is to be applied, and the flaps turned aside with a periosteal elevator. The middle of the flap turned down should be made to correspond to the position of the artery. When the bone has been exposed, a trephine with a diameter of ½ inch is applied to the skull, the pin of the instrument being placed over the position of the

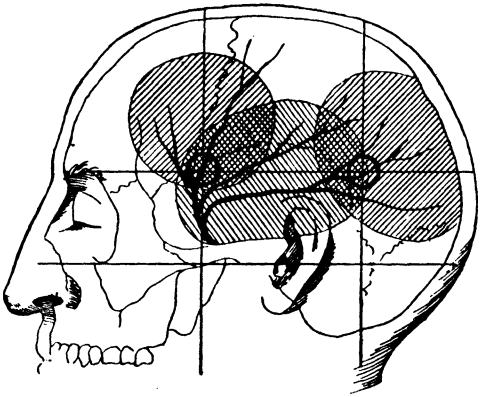

FIG. 358.—Ligature of middle meningeal artery. Position of trephine openings in exposure of anterior and posterior branches.—After KRÖNLEIN.

artery. A circle of bone is then removed, care being taken in using the trephine to avoid injury to the dura mater or to the vessel itself. In those cases in which the vessel lies in a canal or a very deep groove in the bone, it is not always possible in the dead subject to avoid injury to the artery ; but in the living person, when the operation is done for rupture of the artery, the vessel is usually separated slightly from the bone, and lies out of the way of injury, though this will not be the case if it occupies a canal in the bone. When the middle meningeal artery has been exposed in this manner, it will be seen to lie embedded in the external surface of the dura mater, and to be accompanied by two small venæ comites. The artery is separated from the dura mater, and the aneurysm needle passed underneath, and the vessel ligatured together with its venæ comites. When the artery lies in a canal in the bone it may be requisite to plug the open mouth of the bony canal with a small piece of wood, or a portion of surgical wax, in order to arrest hæmorrhage, or to cut away with bone forceps the bone around the aperture of the canal in which it runs, and then to pick up and tie the bleeding vessel.

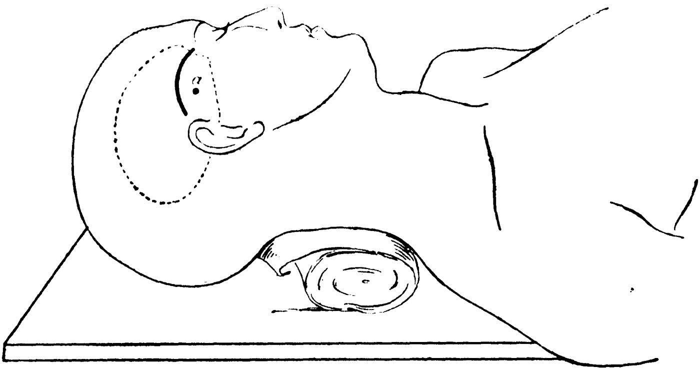

FIG. 359.—Ligature of middle meningeal artery (main branch). Shape of flap and position of application of trephine.

The main trunk of the middle meningeal artery within the cranium.—This vessel may be ligatured through a trephine aperture, placed a little nearer the zygoma than the above. In practice, however, it is usually found convenient first to expose the anterior branch as above, and then to enlarge the opening in the skull downwards with bone forceps until the main trunk is reached. In applying a ligature to the main artery, it will usually be found necessary to push inwards the dura mater for a short distance below the trephine aperture, in order freely to expose the vessel. This can be fairly easily effected in most cases with the periosteal elevator.

The posterior branch of the middle meningeal artery.—This vessel may be ligatured in a manner similar to the above, the trephine aperture being made about 1½ inches above the centre of the base of the mastoid process, and just below and in front of the parietal eminence (Fig. 358).

The internal carotid artery.—This vessel is one of the terminal branches of the common carotid artery, and given off at the level of the upper border of the thyroid cartilage. From this point the artery passes upwards to the base of the skull, where it enters the carotid canal in the petrous bone. At its commencement the internal carotid lies a little external and in a plane somewhat posterior to that of the external carotid. As it passes upwards it takes a course behind the digastric, and is very deeply placed. A ligature is only applied to this artery immediately above its commencement.

Operation.—The skin incision and early stages of the operation are similar to those described for the external carotid (Fig. 353), and when this vessel has been exposed it is retracted to the medial side. The sheath of the internal carotid is thus laid bare, and is opened in the usual manner. The needle is passed from the lateral side so as to avoid injury to the jugular vein. Care must be taken not to include the vagus of the cervical sympathetic trunk, which lies immediately posterior to the artery at this point.

Collateral circulation.—This is established through the communications of the two internal carotids in the circle of Willis within the cranium.

The subclavian artery.—The subclavian artery on the right side arises from the innominate artery behind the sterno-clavicular articulation, and on the left side from the arch of the aorta opposite a point immediately to the left of the centre of the manubrium sterni. The artery on each side terminates at the outer border of the first rib, where it becomes axillary. The course of the vessel is divided into three parts, the first portion being that section which lies internal to the scalenus anticus, the second that which lies behind this muscle, while the third or terminal part extends from the outer border of the scalenus anticus to the outer margin of the first rib. The first and second parts of the vessel are very deeply placed, and almost inaccessible for the application of a ligature. The first part of the artery has been ligatured through an incision similar to that which has been described in the case of the innominate artery.

When the arm lies against the side, the course of the subclavian artery is marked out by drawing a line from the centre of the sterno-clavicular articulation to the central point of the clavicle in such a manner that it describes a curve, the centre of whose convexity is situated about ¾ inch above the clavicle. The thoracic portion of the left subclavian is represented by a line from a point a little to the left of the centre of the manubrium sterni to the left sterno-clavicular articulation.

The third part of the subclavian artery lies somewhat superficial. It is covered in front by a process of the deep cervical fascia, and often overlapped by the lower margin of the posterior belly of the omo-hyoid muscle ; beneath and below which lie the transverse cervical artery and superior and posterior scapular veins arranged in a plexiform manner ; whilst more superficially it has the nerve to the subclavius, the deep fascia, the superficial fascia containing the platysma, the external jugular vein, the supra-clavicular nerves, and the skin. The dome of the pleura lies below and behind the vessel; the upper surface of the rib below ; the scalenus medius posteriorly ; and the cords of the brachial plexus above ; the cord formed by the last cervical and first dorsal nerve being situated nearest and often behind the artery. The subclavian vein is anterior, and at a lower level than the artery. The position of the external jugular vein is somewhat variable, but it will usually be met with in the early part of the operation, lying anterior to the artery. No branches are normally given off from this part of the subclavian artery, but occasionally the posterior scapular or the transverse scapular (suprascapular) artery arises from the third part of the subclavian.

Ligature of the subclavian artery in the third part of its course.—*Position.*—The patient is placed in the dorsal position, the shoulders raised by a hard pillow, the head turned towards the opposite side, and the arm on the side of the operation drawn well down. The surgeon stands opposite the shoulder on the affected side, and the chief assistant immediately opposite to him.

Operation.—With the left hand the skin is drawn downwards over the middle of the clavicle, and an incision 3 inches in length made, extending to the bone, and dividing the skin, platysma, superficial fascia, and the descending cervical nerves which lie in it. The skin is allowed to retract upwards, and then the deep fascia is incised for the full extent of the incision. In this part of the operation the external jugular vein may be met with, in which case it is either ligatured in two places and divided or pulled inward and upwards out of the field of operation. Great care must be taken not to wound the vein before ligatures are supplied, since its wall is closely united to the margins of the aperture by which it passes through the deep fascia ; and if it be wounded, air is liable to be drawn inwards, owing to negative pressure which normally exists in the blood stream in this vessel. If the patient is muscular, the posterior border of the sterno-mastoid and the anterior border of the trapezius will be exposed, and it may be requisite to divide them at the extremities of the incision. When the deep fascia has been fully divided, the posterior belly of the omo-hyoid is sought for immediately above the clavicle, and its inferior margin defined, and then the entire structure is drawn upwards. The position of this muscle varies according to the degree to which the arm is drawn downwards. When the omo-hyoid has been distinguished its lower border is traced inwards, and the fascia which lies below it incised, the small nerve which passes downwards to the subclavius muscle being generally cut at the same time. The plexus of veins in this neighbourhood must then be carefully divided or drawn aside. When this has been done the lateral border of the scalenus anterior is sought for in the inner part of the wound, and when found it is traced downwards until its insertion into the scalene tubercle on the inner border of the first rib can be felt. When this tubercle has been defined the fascia immediately above and behind it is carefully divided, when the subclavian artery will be exposed in the third part of

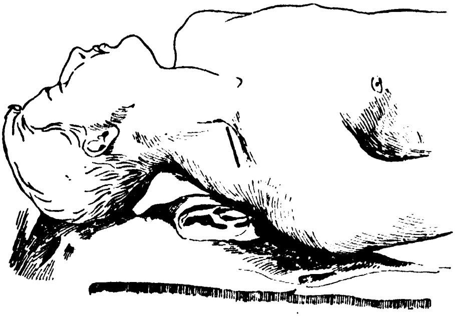

FIG. 360.—Ligature of subclavian artery. Position of patient, and line of skin incision.

its course, lying in a groove on the rib. When the artery has been exposed in this way, it will usually be seen to have almost a vertical course, and the ligature will be applied a little above the first rib. The sheath of the vessel is opened in the usual manner, and separated for a short distance, and the aneurysm needle passed from the nerves which lie above the artery. Care must be taken not to pierce the vein with the needle. The brachial plexus lies at a higher level in the neck, but if the above stages are not carried out it occasionally happens that the lowest cord of the plexus is tied instead of the artery, or is included within the ligature which surrounds the vessel. On the dead subject this mistake is frequently made, owing to the absence of pulsation; whilst the vein may be tied, or even a ligature passed around the posterior belly of the omo-hyoid muscle, or a lymph gland.

Collateral circulation.—This is very free owing to the numerous channels of communication, and is effected by the following vessels:—(*a*) The supreme (superior) thoracic artery, with the superior intercostal and intercostal branches of the internal mammary in the first intercostal space. (*b*) The pectoral branches of the thoraco-acromial and the long thoracic, with the intercostal branches of the internal mammary and the thoracic aorta in the upper four or five intercostal spaces. (*c*) The subscapular artery, with the intercostal branches of the thoracic aorta in the second to the sixth spaces, and by means of its dorsalis scapulæ branch with the transverse scapular (suprascapular) and descending branch of the transverse cervical branch of the subclavian. (*d*) Acromial branches of the thoraco-acromial artery, with similar branches from the transverse cervical (suprascapular) artery.

The inferior thyroid artery.—This artery supplies the lower and deep aspect of the lateral lobe of the thyroid gland. It passes behind the common carotid sheath about the level of the sixth cervical vertebra. It gives off the ascending cervical artery, and a ligature is usually applied distal to the origin of this vessel.

Position.—The positions of the patient, surgeon, and assistant are the same as for ligature of the common carotid in the lower part of its course.

Operation.—The incision and the different stages of the operation are similar to those for ligature of the common carotid below the omo-hyoid. When the carotid sheath has been exposed the fascia on its medial side is divided, and the entire sheath with its contents retracted to the lateral side. In the interval on the medial side of the sheath the carotid tubercle of the sixth cervical vertebra is sought for ; and immediately below this, the inferior thyroid artery will be found running medially from behind the sheath. The vessel is carefully separated from the surrounding structures, and the ligature applied, the needle being passed from the lateral side.

The vertebral artery.—The vertebral artery is a branch of the first part of the subclavian artery, and from its point of origin passes upwards to enter the costo-transverse foramen of the sixth cervical vertebra, immediately behind the carotid tubercle.

Operation.—The operation for its ligature is similar to that for the common carotid below the omo-hyoid muscle, or for the inferior thyroid artery. When the carotid tubercle has been defined, the margins of the wound are well retracted, and at the same time the inferior thyroid artery is hooked downwards. By careful dissection, the vertebral artery will be discovered lying surrounded by its venæ comites, in the space immediately below and posterior to the carotid tubercle. When the artery has been exposed, the vein, if possible, is drawn to the lateral side, and the aneurysm needle is passed from without medially, care being taken not to include any of the branches of the cervical sympathetic which lie in close proximity.

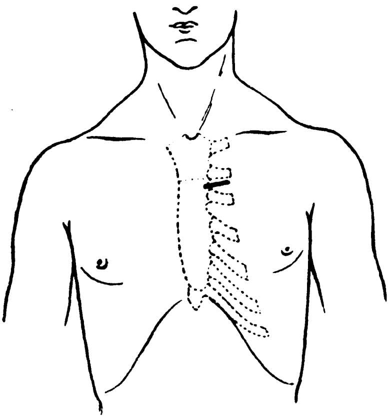

FIG. 361.—Ligature of internal mammary artery. Position of skin incision.

Collateral circulation.—This is established through the various communications of the two sides in the circle of Willis.

The internal mammary artery.—The internal mammary artery is a large branch given off from the first part of the subclavian. It passes downwards, lying first behind the sterno-clavicular articulation, and then behind the costal cartilages and intercostal spaces, about ½ inch outside the lateral margin of the sternum. Opposite the lower border of the sixth costal cartilage it terminates by dividing into the superior epigastric and the musculo-phrenic arteries.

The course of the vessel is indicated by drawing a line from the central point of the sterno-clavicular joint downwards to the sixth costal cartilage, or the sixth interspace, about ½ inch from the margin of the sternum.

The internal mammary artery lies upon a thin layer of fascia which separates it from the parietal pleura in the upper part of the thorax, and lower down upon the transversus thoracis muscle (triangularis sterni).

Position.—The patient is placed in the dorsal position. The surgeon stands on the affected side, and the assistant on the opposite side.

Operation.—An incision about 1½ inches long is made across the middle of one of the intercostal spaces, preferably the second or third, commencing a short distance from the middle line of the sternum, and extending laterally at right angles to the course of the artery (Fig. 361). This incision divides the skin, superficial fascia, deep fascia, sternal fibres of the pectoralis major muscle, anterior intercostal membrane, and lastly the internal intercostal muscle, when the artery will be exposed lying upon the pleura and having a vein usually on each side. The needle is passed from the lateral side. In making the incision, great care must be exercised to avoid puncturing the pleura, and notching the underlying lung, or dividing the vessel itself transversely, as it lies on the pleura. It is much more difficult to apply a ligature to the vessel in the lower intercostal spaces, on account of the small distance between the adjacent costal cartilages.

Collateral circulation. — This is established through the anastomoses of the intercostal branches of the internal mammary with similar branches from the superior intercostal or from the thoracic aorta, and through the communication of the superior epigastric artery with the inferior (deep) epigastric in the region of the umbilicus.

The axillary artery.—The axillary artery is the continuation of the subclavian. It commences at the lateral border of the first rib, and terminates at the lower border of the teres major, where this muscle forms the posterior fold of the axilla.

At its commencement the artery lies behind the central part of the clavicle and the subclavius muscle, then behind the costo-coracoid membrane, which separates it from the clavicular portion of the pectoralis major, next behind the pectoralis minor, then behind that part of the pectoralis major which forms the anterior fold of the axilla, and finally behind the deep fascia of the arm as it becomes continuous with the pectoral fascia. That portion of the artery which extends between the outer border of the first rib and the upper border of the pectoralis minor is called the first part, and measures usually a little more than an inch in length; the second part lies behind the pectoralis minor, and measures a little less than an inch; whilst the third part comprises the remainder of the vessel, and extends from the lower border of the pectoralis minor to the lower margin of the teres major, measuring a little more than 3 inches in length. The first part of the artery lies upon the upper two serrations of the serratus anterior (serratus magnus) muscle, as they cover the first intercostal space and the second rib, and also behind it are the posterior thoracic nerve and the connective tissue which lies between the serratus anterior (serratus magnus) and subscapularis; the second portion lies upon the posterior cord of the brachial plexus, but is separated from the subscapularis by a mass of fat; whilst the third part has the radial (O.T., musculo-spiral) and circumflex nerves behind it, and also the lower part of the subscapularis, and the latissimus dorsi and teres major tendons. The axillary vein lies on the medial side of the vessel and on a slightly anterior plane for its entire course, but separated by the ulnar nerve in the lower part. On the lateral side, and above the first portion, there is the brachial plexus; the second part of the artery is surrounded by the cords of the plexus; and in the third part of its course the branches of the plexus lie around it. The third part of the artery is often crossed by the lateral vena comes of the brachial artery as it passes inwards to join the medial vena comes to form a common trunk which opens into the axillary vein at the lower border of the subscapularis.

The course of the axillary artery is marked out by placing the limb at right angles to the trunk with the forearm supinated, and drawing a line from the central point of the clavicle to the middle of the cubital fossa. This line marks out both brachial and axillary arteries, the axillary extending from the clavicle to the lower margin of the posterior fold of the axilla.

The axillary artery may be ligatured in the first or third part of its course, the former operation being the more difficult, and very rarely performed except on the dead body.

Ligature of the first part of the axillary artery.—*Position.*—The patient is placed in the dorsal position near the edge of the table, with a flat pillow underneath the scapular region of the affected side, so as to press inwards the scapula towards the spine; the arm lies by the side, but the point of the shoulder is not depressed. The surgeon stands at the outer side of the upper part of the limb when operating on the left side, and opposite the tip of the shoulder when the artery on the right side is to be dealt with. The chief assistant stands directly opposite the operator.

Operation.—An incision about 4 inches long is made, commencing immediately below and two-thirds of an inch lateral to the sterno-clavicular articulation, and extending to the medial side of the apex of the coracoid process (Fig. 362). The skin, superficial fascia containing platysma and supra-clavicular nerves, the deep fascia covering the pectoral muscle, and the clavicular portion of the pectoralis major, are divided in the line of the incision, care being taken to avoid the cephalic vein as it lies in the lateral portion of the wound. The pectoralis major may either be detached from the clavicle or its fibres cut through. The margins of the wound are retracted and the costo-coracoid membrane sought for, the subclavius being defined above and the pectoralis minor below. The costo-coracoid membrane is next incised, and the cephalic vein and other structures which pierce it pulled aside, together with the exposed muscles (subclavius and pectoralis minor). The pectoralis minor is retracted laterally. The first part of the axillary artery will then be visible, with the vein lying to the medial side and somewhat overlapping it. The sheath is opened in the usual manner, and the needle passed from below so as to avoid damage to the vein. The brachial plexus lies at a higher level, but in the dead body it is possible to apply a ligature to one of the cords instead of the artery. The ligature may be applied to the vessel above or below the origin of the supreme thoracic and thoraco-acromial arteries. In the former case the *collateral circulation* will be the same as after ligature of the third part of the subclavian, and in the latter the humeral branch of the thoraco-acromial will form a communication with the anterior circumflex, and the pectoral branches with similar branches from the long thoracic. In some cases, such as very stout or muscular patients, a transverse incision semilunar in shape with the convexity downwards, commencing half an inch external to the sternal end of the clavicle and extending to a point half an inch internal to the coracoid, may be made and a flap turned upwards. This

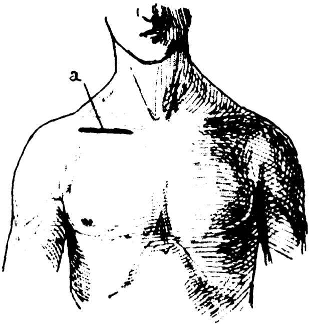

FIG. 362.—Ligature of axillary artery (first part).
a. Position of skin incision.

gives more room for the surgeon to work in than the former incision.

Ligature of the first part of the axillary artery.—*Position.*—The patient is placed in the dorsal position, with the affected limb at right angles to the trunk, and supinated. The surgeon stands between the limb and the trunk opposite the axilla, and the chief assistant on the outer side of the upper arm opposite the operator.

Operation.—An incision 3 inches long is made in the line of the artery, commencing above at a point a third of the distance from the anterior to the posterior fold of the axilla (Fig. 362, *a*). This incision divides the skin, superficial fascia, and deep fascia, and when the margins of the wound are retracted the artery is exposed. The lateral vena comes of the brachial artery often crosses it, whilst the median nerve, or its medial head, lies in front of it, and the coraco-brachialis overlaps it from the lateral side. The median and musculo-cutaneous nerves, together with the coraco-brachialis muscle, are drawn to the lateral side, the artery is separated from the adjacent veins—which in the lower part of the axilla may be numerous—and the aneurysm needle passed from the medial side, care being taken not to include the ulnar and medial (internal) cutaneous nerves, which lie on the medial side, or the radial nerve which lies behind.

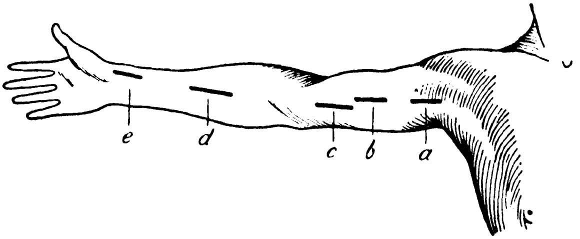

FIG. 363.—Ligature of arteries of upper extremity.

a. Incision for third part of the axillary artery.
b. Incision for brachial at middle of arm.
c. Incision for brachial at end of elbow
d. Incision for radial at middle of forearm.
e. Incision for radial at wrist.

Collateral circulation.—The channels by which the collateral circulation is established, after ligature of the third portion of the axillary, vary according to the position of the ligature.

When the ligature is applied above the origin of the subscapular artery, they are—(*a*) The posterior circumflex of the humerus with acromial branches of the thoraco-acromial and the transverse scapular (suprascapular); (*b*) the subscapular, by means of its dorsal scapular branch, with the transverse scapular and the descending branch of the transverse cervical, and by its thoracic branches with similar branches from the intercostal arteries of the upper four to six spaces, and also from the long thoracic.

When the ligature is applied between the subscapular and the circumflex arteries, the chief channels are the communications between the posterior circumflex of the humerus and the acromial branches of the thoraco-acromial and transverse scapular arteries (suprascapular).

If the ligature is placed below the circumflex arteries, the channels are similar to those after ligature of the brachial above the profunda, namely, communications between ascending branches of the profunda and branches of the circumflex arteries of the humerus, chiefly the posterior.

The brachial artery.—The vessel commences at the lower border of the teres major, and terminates in the cubital fossa, anterior and slightly to the medial side of the neck or head of the radius, by dividing into the ulnar and radial arteries.

Its course has been marked out along with that of the axillary artery.

The artery lies upon the long head of the triceps brachii, the radial (musculo-spiral) nerve and profunda (superior profunda) artery, then upon the medial head of the triceps, the insertion of the coraco-brachialis, and finally upon the brachialis muscle.

For the greater part of its extent it is superficial, but at the elbow it lies underneath the lacerta fibrosus (bicipital fascia) and between the brachio-radialis and pronator teres muscles. It is overlapped, especially in muscular subjects, by the biceps, and it is crossed from without medially (usually about the middle of the arm) by the median nerve. The vessel has two venæ comites, one on each side, these structures often being connected by large cross branches.

The artery may be ligatured in the middle of the upper arm, or at the bend of the elbow.

Ligature of the brachial artery at the middle of the arm.—*Position.*—The patient is placed on his back near the edge of the table; the arm is abducted to a right angle, and held in the supine position. An assistant should stand on the outer side of the limb, and support it at the elbow or allow the elbow, but not the upper arm, to rest on a small table, otherwise the triceps may affect the position of the biceps and so obscure the vessel. The operator stands between the limb and the trunk, and a second assistant opposite him.

Operation.—An incision 2½ inches long is made in the line of the vessel, its central point corresponding to the middle of the upper arm (Fig. 363, *b*). The skin, superficial fascia containing the basilic vein, and the deep fascia are divided, and the medial border of the biceps muscle exposed. Care must be exercised not to mistake the triceps for the biceps, and to avoid injury to the basilic vein. The biceps is retracted outwards, the artery not being included under the retractor, when the artery will be

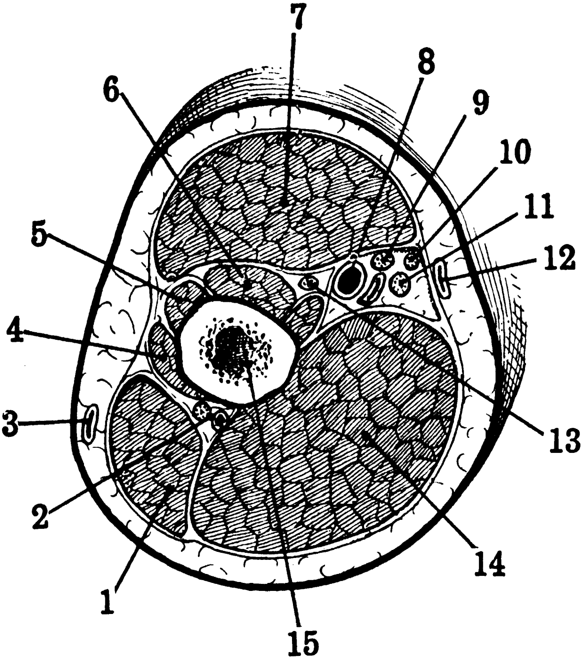

Fig. 364.—Transverse section of upper arm. Lower part of middle third.

1. Triceps (musculo-spiral) brachii.
2. Radial nerve and profunda (superior profunda) artery.
3. Cephalic vein.
4. Brachio-radialis.
5. Brachialis.
6. Brachialis.
7. Biceps humeri.
8. Brachial artery.
9. Median nerve.
10. Medial (internal) cutaneous nerve.
11. Ulnar nerve.
12. Basilic vein.
13. Musculo-cutaneous nerve.
14. Triceps.
15. Humerus.

exposed lying upon the triceps, surrounded by its venæ comites, and with the median nerve usually in front. The median nerve is drawn to whichever side is most convenient, the artery separated from its venæ comites, and the needle passed from the nerve. In the dead subject the basilic vein is occasionally ligatured instead of the artery, but this mistake can be easily prevented by taking care that the deep fascia is divided and the biceps exposed.

Collateral circulation.—If the ligature is applied above the origin of the profunda (superior profunda), the collateral circulation is established by communications between ascending branches of the profunda (superior profunda) with branches of the circumflex arteries, especially the posterior. When it is ligatured between the (superior profunda) profunda and ulnar collateral (inferior profunda) vessels, the principal communications are between the inferior ulnar collateral (inferior profunda), the radial recurrent, and the interosseous recurrent, with the terminal branches of the profunda.

If below the origin of both profunda arteries, in addition to the above, inferior ulnar collateral, and the anterior and posterior ulnar recurrent with the inferior ulnar collateral.

Ligature of the brachial artery at the bend of the elbow.—*Position.*—Similar to that for ligature of the artery in the middle of the arm, except that the limb may rest on the table.

Operation.—An incision about 2 inches long is made, commencing on the right side immediately above and medial to the central point of the bend of the elbow, and extending upwards and medially, parallel with the medial border of the biceps muscle (Fig. 363, *c*). The skin, superficial fascia containing the superficial veins and nerves, and the deep fascia, which is strengthened by the lacertus fibrosus (bicipital fascia), are divided, the veins and nerves being retracted as they become visible. The vessel is now exposed, surrounded by its venæ comites, and with the median nerve on its medial side and the biceps on the lateral side. The vessel is separated from its veins, and the needle passed from the medial side.

Collateral circulation.—This is established along the channels which have been enumerated, after ligature of the brachial below the profunda (superior profunda) and the superior ulnar collateral (inferior profunda) arteries.

The ulnar artery.—The ulnar artery is one of the terminal branches of the brachial; it commences in the cubital fossa, and terminates beyond the pisiform bone by dividing into superficial and deep branches.

In its course downwards it lies upon the insertion of the brachialis, then upon the flexor digitorum profundus, and finally on the transverse carpal ligament. In the upper part of its course it lies behind some of the flexor group of muscles which come from the medial epicondyle ; in the next part it is overlapped by the flexor carpi ulnaris, and in the region of the wrist it is covered by the piso-annular band of fascia and skin only. The ulnar nerve lies on its ulnar side for the distal half of the forearm. The course of the artery is represented in the distal two-thirds of the forearm by drawing a line from the medial epicondyle of the humerus to the radial side of the pisiform bone, and in the proximal third by continuing the course of the vessel upwards to the central point of the cubital fossa.

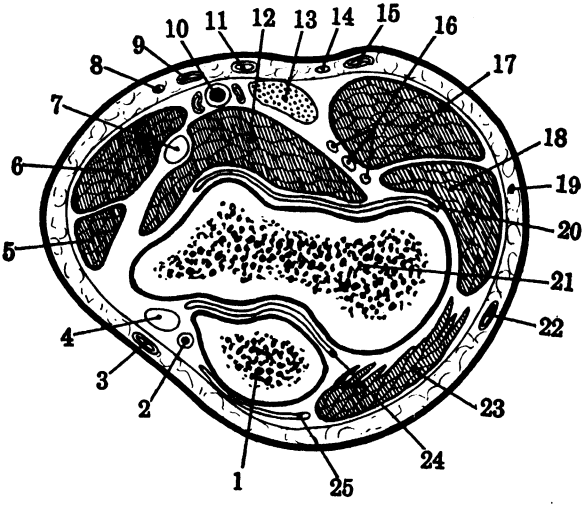

FIG. 365.—Transverse section of left arm immediately above condyles of humerus.

1. Olecranon.
2. Superior ulnar collateral (inferior profunda artery).
3. Cutaneous vein.
4. Ulnar nerve.
5. Flexor carpi radialis.
6. Pronator teres.
7. Median nerve.
8. Medial cutaneous nerve.
9. Basilic vein.
10. Radial artery and vein.
11. Median vein.
12. Brachialis muscle.
13. Biceps tendon.
14. Lateral cutaneous nerve.
15. Cephalic vein.
16. Posterior interosseous and cutaneous division of radial nerve.
17. Brachio-radialis (supinator longus).
18. Extensor carpi radialis longus.
19. Lateral cutaneous nerve.
20. Synovial membranes of elbow-joint.
21. Humerus.
22. Superficial vein.
23. Anconæus.
24. Synovial membrane of elbow-joint.
25. Olecranon bursa.

The artery may be ligatured in the proximal middle or distal third ; in the proximal third it is very deeply placed.

Ligature of the ulnar artery in the proximal third.—*Position.*—The arm is placed at right angles to the body on a small table, and held in the supine position. The surgeon stands on the inner or outer side of the arm, and the assistant opposite to him.

Operation.—A point is taken midway between the epicondyles of the humerus, and an incision made downwards from this in the line of the artery. The skin, superficial fascia containing branches of the medial (internal) cutaneous nerve, the median basilic and anterior ulnar veins are divided, the latter structures being drawn aside. The deep fascia, thickened in this situation to form the lacertus fibrosus (bicipital fascia), is then divided in the line of the incision, and the radial border of the pronator teres defined. This structure is drawn to the medial side, together with the median nerve which lies immediately beneath it, and the artery sought as it passes under the muscle.

It is carefully separated from the surrounding veins, and the needle passed from the radial side.

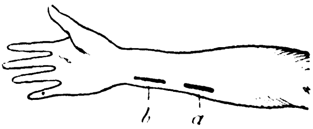

Fig. 366.—Ligature of ulnar artery. Position of skin incisions.
a. In middle third of forearm.
b. In distal third of forearm.

Ligature of the ulnar artery in the middle third of the forearm.—*Position.*—As for ligature at the bend of the elbow.

Operation.—An incision from 2½ to 3 inches long is made in the line of the vessel, the central point corresponding to the midde of the forearm (Fig. 366, *a*). The skin, superficial fascia containing the anterior ulnar vein and branches of the medial (internal) cutaneous nerve, and the deep fascia, are divided, the muscles are exposed, and the interval between the flexor carpi ulnaris and the flexor digitorum sublimis sought for with the finger. When this has been found the muscles are separated, and the artery will be seen lying upon the flexor digitorum profundus, surrounded by its venæ comites, and with the ulnar nerve on its medial side. The vessel is now separated from its accompanying veins, and the needle passed from the medial side.

Ligature of the ulnar artery in the distal third of the forearm.—*Position.*—As for ligature in the middle third.

Operation.—An incision about 2 inches long is made in the line of the vessel, commencing about 1 inch above the radial side of the pisiform bone and extending upwards (Fig. 366, *b*). The skin, superficial fascia, and deep fascia are divided, and the artery sought for in the interval between the flexor carpi ulnaris and flexor digitorum sublimis muscles. The artery, when exposed, is separated from the ulnar nerve, which lies on the medial side, and also, if possible, from the venæ comites, and then the needle is passed from the medial side.

Collateral circulation.—This is very easily established through the free communications of the palmar arches, and also through the anterior and posterior interosseous arteries and the carpal arches.

The radial artery.—The radial artery commences at the bifurcation of the brachial at the bend of the elbow, and terminates on the dorsal aspect of the wrist, where it passes between the two heads of the first dorsal interosseous muscle to enter into the formation of the deep palmar arch.

Its course is represented by a slightly curved line with the convexity laterally drawn from the central point of the cubital fossa to a fossa about half-way between the tuberosity of the navicular and the styloid process of the radius, whence it winds round the lateral aspect of the wrist across the " tabatière " to the base of the first intermetacarpal space.

It lies upon the tendon of the biceps, the supinator muscle (supinator brevis), the pronator teres, the radial head of the flexor sublimis digitorum, the flexor pollicis longus, the pronator quadratus, the anterior aspect of the lower end of the radius, the anterior and lateral ligaments of the wrist-joint, and finally on the dorsal surface of the navicular (scaphoid) and os multangulum majus (trapezium). In the first part of its extent it is covered by the brachio-radialis, then it sets superficially, and lastly it passes beneath the extensor muscles of the thumb. It is accompanied by two venæ comites, but the radial nerve lies in contact with the vessel on the radial side for the middle third only of its course.

The radial artery may have a ligature applied to it in the proximal middle and distal thirds of the forearm, and also as it lies in the " tabatière " on the dorsal aspect of the wrist.

Ligature of the radial artery in the proximal third.—*Position.*—As for the ulnar artery.

Operation.—An incision a little over 2 inches in length is made in the proximal third of the forearm, in the line of the vessel. The skin, superficial and deep fasciæ, are divided, and the interval between the brachio-radialis (supinator longus) and the pronator teres sought for. The fibres of the former muscle run in a vertical direction, and those of the latter obliquely downwards and outwards. When this interval has been defined the muscles are separated and the artery exposed. The needle may be passed from either side, the vessel being separated from its venæ comites if possible.

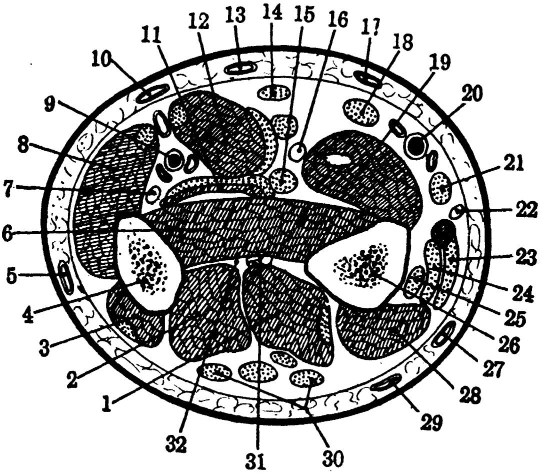

Fig. 367.—Transverse section of forearm through upper portion of lower fourth.

1. Extensor pollicis longus (extensor secundi internodii pollicis).
2. Extensor proprius indicis.
3. Extensor carpi ulnaris.
4. Ulna.
5. Tributary of anterior ulnar vein.
6. Pronator quadratus.
7. Ulnar nerve.
8. Flexor carpi ulnaris.
9. Ulnar artery.
10. Anterior ulnar vein.
11. Flexor digitorum profundus.
12. Flexor digitorum sublimis.
13. Superficial median vein.
14. Palmaris longus.
15. Lateral tendon of flexor digitorum profundus.
16. Median nerve.
17. Anterior radial vein.
18. Flexor carpi radialis.
19. Flexor pollicis longus.
20. Radial artery.
21. Brachio-radialis (supinator longus).
22. Cutaneous branch of radial nerve.
23. Abductor pollicis longus.
24. Extensor carpi radialis longus.
25. Extensor carpi radialis brevis.
26. Radius.
27. Posterior radial vein.
28. Extensor pollicis brevis (extensor primi internodii pollicis).
29. Superficial vein.
30. Extensor digitorum communis.
31. Anterior interosseous vessels and nerve.
32. Radio-ulnar interosseous membrane.

Ligature of the radial artery in the middle third.—*Position.*—As in the preceding operation.

Operation.—An incision from 2 to 3 inches long is made in the middle third of the forearm over the line of the artery (Fig. 363, *d*). The skin, the superficial fascia containing the radial vein and branches of the musculo-cutaneous nerve, and the deep fascia are divided, care being taken not to injure the superficial veins or nerves. The medial border of the brachio-radialis (supinator longus), which in this position is muscular above and tendinous below, is defined, and the muscle retracted towards the lateral side. The radial vein lies on the lateral side, but some distance away from the vessel. The artery is then exposed, lying upon the insertion of the pronator teres and surrounded by its venæ comites. These latter structures are separated from the vessel, and the needle passed from whichever side is found to be the more convenient.

Ligature of the radial artery in the distal third.—*Position.*—As for ligature of the vessel in the middle third.

Operation.—An incision about 1½ inches in length is made, commencing a little above the level of the tuberosity of the navicular (scaphoid) and extending upwards in the line of the artery (Fig. 363, *e*). The skin and fascia are divided, and the interval between the medial border of the brachio-radialis (supinator longus) and the lateral margin of the flexor carpi radialis opened up, care being taken not to injure the superficial veins or to divide the artery longitudinally as it lies in the bottom of the wound. The venæ comites are separated, and the needle passed from either side. In many cases it will be found necessary to include the veins in the ligature.

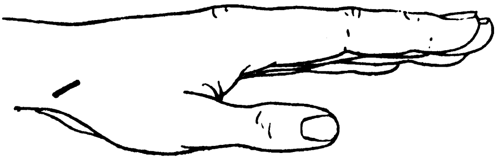

FIG. 368.—Ligature of radial artery on dorsum of wrist. Position of hand and line of skin incision.

Ligature of the radial artery on the dorsum of the wrist.—*Position.*—The hand is placed in a position half-way between supination and pronation resting on its ulnar border, and held by an assistant. The surgeon stands on the outer side of the limb, and the assistant opposite to him.

Operation.—An oblique or almost vertical incision about 1 inch in length is made, commencing immediately distal to the styloid process of the radius, and running across the " tabatière," half-way between the tendon of the extensor pollicis brevis (extensor primi internodii pollicis) and that of the extensor pollicis longus (extensor secundi internodii pollicis) (Fig. 368). The skin and fasciæ are divided, the margins of the incision retracted, and then the artery will be exposed, lying upon the dorsal aspect and lateral side of the wrist. The needle is passed from either side. Care must be taken, in the performance of this operation, to avoid injury to the adjacent tendon sheaths or the underlying joints.

Collateral circulation.—The collateral circulation, after ligature of the radial artery, is established in a manner similar to that which occurs when the ulnar artery is occluded.

Ligature of an intercostal artery.—In each intercostal space intercostal arteries are found, one above and one below, the former being the larger. Each vessel lies in a groove in the rib, which forms a boundary of the intercostal space (Fig. 452). It is occasionally necessary to apply a ligature to the vessel as it lies in this groove.

Position.—The patient is so placed that the area of the operation is well exposed.

Operation.—An incision about 2 inches in length is made over the rib, and in the direction of the blood vessel which it is proposed to ligature. The surface of the rib is exposed, the periosteum separated, and a portion of the rib overlying the vessel removed subperiosteally. When this has been done and the periosteum divided, the artery is laid bare, and a ligature can be applied easily. In cases of injury, usually, it will be found requisite to place a ligature on each extremity of the artery as it lies exposed in the bottom of the wound, on account of the free anastomoses between the vessels in each intercostal space.

Abdominal Aorta.—The abdominal aorta lies upon the anterior aspect of the posterior abdominal wall, its point of bifurcation being upon the left side of the lower portion of the body of the fourth lumbar vertebra.

This is marked out on the surface of the abdomen by taking a point which is two finger-breadths above the transpyloric plane to the mid-line and drawing a line downwards to a point ½ inch to the left of the middle of the intertubercular plane or to a point ¾ inch below and ½ inch to the left of the umbilicus. The inferior vena cava lies to the right of the aorta, and tends to overlap it, whilst it is surrounded by the aortic plexus of the sympathetic, and has lying in front of it, just above its bifurcation, the inferior mesenteric artery, the parietal peritoneum, and the small intestines.

The vessel has only been ligatured a few times; all the cases have been fatal, usually within a few hours, but one case lived for ten days.

Position.—The patient is placed in the dorsal position. The surgeon stands upon the right side and the chief assistant upon the left.

Operation.—An incision 3 or 4 inches in length is made ½ inch to one or other side of the linea alba, one-third of the incision being below the point of bifurcation and two-thirds above (Fig. 369). The peritoneum is opened for the entire length of the incision; the small intestines and large omentum are pushed upwards and to the right, and held there by the hands of an assistant or by large flat sponges, and in this way the anterior aspect of the lower portion of the vessel is exposed, except that it is covered with peritoneum. This peritoneum is divided by a vertical incision, and lifted away from the vessel by the finger. The inferior mesenteric artery is then defined and pushed over to the left, and a point half-way between the origin of this vessel and the bifurcation of the aorta is selected for the application of the ligature. The vessel is then separated from the connective tissue and the plexus of sympathetic nerves which surrounds it, and a large curved aneurysm needle passed from the right side. This is threaded with a thick silk ligature and withdrawn. The ligature is then tied, the ends cut short, and the peritoneum replaced, and united with interrupted silk suture. All sponges are then removed, and the external wound closed.

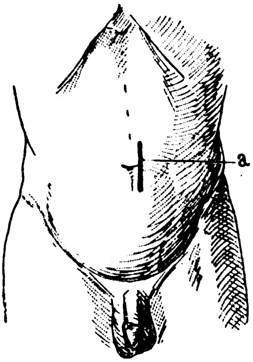

Fig. 369.—Ligature of abdominal aorta.

a. Position of parietal incision.

The above is the *intraperitoneal* method of operation. An *extraperitoneal* operation has been performed, but this was made use of in the pre-aseptic days.

The common iliac artery.—A slightly curved line with its convexity outwards, drawn from the point of bifurcation of the abdominal aorta to the central point of a line from the anterior superior iliac spine to the symphysis pubis, represents the course of the common and external iliac arteries, the upper third corresponding to the common iliac and the lower two-thirds to the external iliac vessel.

The common iliac artery extends from the lower part of the fourth lumbar vertebra to a point opposite the lumbo-sacral articulation. It is covered in front by peritoneum, branches of the sympathetic passing to the hypogastric plexus, and at its point of division it is crossed by the ureter. The right common iliac artery is in relation with the commencement of the inferior vena cava and both common iliac veins. Each common iliac vein lies posterior and internal to the corresponding artery at first, but the left vein crosses behind the upper portion of the artery of the right side, and there joins the right vein, which has already passed behind, so as to form the inferior vena cava. The operation of ligature of the common iliac artery may be carried out through the peritoneum, when the procedure is known as *intraperitoneal,* or it may be performed *extraperitoneally* through either an anterior or a lateral incision.

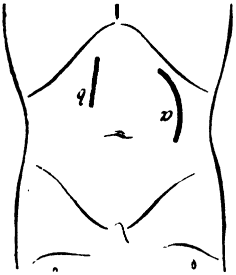

FIG. 370.—Ligature of common iliac artery.

a. Incision for extraperitoneal operation on right side.
b. Incision for intraperitoneal operation on left side.

The *intraperitoneal* operation is preferable, owing to the ease with which the vessel can be exposed, and the lessened dangers of injury to adjacent viscera.

Intraperitoneal operation.—*Position.*—The patient is placed in the dorsal position, with the side which is to be operated upon slightly raised. The surgeon stands on the same side of the patient as the artery, and the chief assistant on the opposite side.

Operation.—An incision about 4 inches long is made ½ inch to one or other side of the linea alba or the linea semilunaris, commencing below at a point one-third of the distance from the symphysis pubis to the umbilicus, and extending upwards beyond the umbilicus (Fig. 370, *b*). The peritoneal cavity is opened, the intestines and large omentum pushed upwards and towards the sound side, and kept out of the field of operation by flat sponges or the hands of an assistant, and the position of the vessel defined as it lies behind the peritoneum a short distance below the point of bifurcation of the aorta. The peritoneum over the artery is divided for about 1 inch in front of the middle portion, care being taken not to injure the ureter or the branches of the sympathetic. With a long, curved aneurysm needle the artery is separated from its sheath for nearly ½ inch, and then the needle is passed from the inner side, threaded and withdrawn. The ligature is then tied, and the ends cut short. If a long incision has been made through the peritoneum in front of the artery, the margins may be approximated with one or two points of interrupted suture; usually this is unnecessary. All sponges are removed, and the parietal wound closed in the usual manner.

Extraperitoneal operation.—(*a*) BY ANTERIOR INCISION.—*Position.*—As for the preceding.

Operation.—An incision from 5 to 8 inches long is made, commencing 1½ inches above and immediately to the outer side of the central point of the inguinal ligament, and curving upwards and laterally first to within 1½ inches of the anterior superior spine of the ilium, then more vertically upwards towards the costal margin, and finally medially in the direction of the umbilicus (Fig. 370, *a*). The various strata of the abdominal wall are divided until the layer of extraperitoneal fatty tissue is recognised, when the peritoneal sac is separated by the fingers from the iliac fascia until the external iliac artery is seen. The latter is traced upwards until the common iliac artery is reached, the ureter and the sympathetic nerves are pushed aside, and the common iliac artery cleared. The ligature is passed in a manner similar to that described in the intraperitoneal operation. After the ligature has been applied the parietal wound is closed by the insertion of two or three tiers of sutures which accurately approximate the different muscular strata and the skin.

(*b*) BY LATERAL INCISION.—*Position.*—The patient is placed well upon the sound side. The surgeon and assistant stand as in the operation through an anterior incision.

Operation.—A somewhat curved incision, with the concavity towards the umbilicus, is made, commencing above at the tip of the twelfth rib and extending obliquely downwards to just above the iliac crest, and then forwards until a point immediately above the anterior superior spine of the ilium is reached. The incision is deepened until the fascia transversalis has been divided and the extraperitoneal tissue exposed. With the fingers the peritoneal sac is separated from the iliac and psoas fasciæ and lifted forwards, when the common iliac artery is seen exposed in the bottom of the wound. The vessel is then separated from the ureter and the common iliac vein, and a ligature passed, the needle being entered on the medial side of the artery. The ligature is then tied, the ends cut short, the incision in the peritoneum sutured, and the external wound closed.

Collateral circulation.—(*a*) Superior epigastric artery and branches from the lower intercostal vessels, with the inferior (deep) epigastric, a branch of the external iliac. (*b*) The lower lumbar arteries, branches of the abdominal aorta, with the iliolumbar, a branch of the hypogastric (internal iliac), and the deep circumflex iliac, a branch of the external iliac. (*c*) The middle-sacral artery, a branch of the abdominal aorta, with the lateral sacral branches of the internal iliac. (*d*) The terminal branches of the inferior mesenteric, with rectal branches of the hypogastric (internal iliac). (*e*) Pubic branches of the obturator, with similar branches from the opposite side. (*f*) In the female, branches of the internal pudendal artery, with similar branches from the opposite side chiefly in the perineum. (*g*) Branches of the uterine artery, from the hypogastric (internal iliac) with the ovarian, a branch of the abdominal aorta.

The external iliac artery.—The line of the external iliac artery has already been mentioned in connection with that of the common iliac.

The vessel lies upon the brim of the pelvis to the medial side of the psoas magnus muscle above, but at the inguinal ligament (Poupart's) it lies directly in front of this structure, though separated from it by the iliac fascia. The lower coil of the ileum crosses the vessel on the right, and the pelvic colon on the left; whilst on both sides the vessel is covered by peritoneum, and crossed at its lower part in the male by the ductus (vas) deferens and the spermatic vessels, and in the female by the round ligament of the uterus. A short distance above the inguinal ligament (Poupart's) the deep circumflex iliac vein crosses the artery to join the external iliac vein.

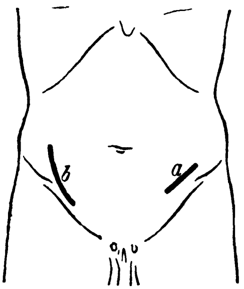

FIG. 371.—Ligature of external iliac artery.

b. Incision for Abernethy's operation.
a. Incision for Cooper's operation.

Position.—The patient is placed in the dorsal position, with the thigh of the affected side slightly flexed and rotated outwards. The operator stands on the same side of the patient as the vessel which is to be ligatured, and the assistant on the opposite side.

Operation.—An incision from 3½ to 4 inches long is made, which commences at a point ½ inch above and medial to the central point of the inguinal ligament (Poupart's), and extends laterally beyond the anterior superior iliac spine, the main part of the incision being parallel with the ligament, while the last inch is curved slightly upwards. The incision divides the various strata of the anterior abdominal wall until the transversalis fascia is reached. This is carefully picked up with forceps at the medial part of the wound, and divided for the entire length of the incision, care being taken not to injure the adjacent portion of the peritoneum. The peritoneum is next peeled upwards with the fingers from the fascia which covers the iliacus and the psoas magnus, until the artery is seen lying upon the medial margin of the muscle, care being taken, especially when performing the operation on the dead body, not to lift up the vessel with the peritoneum, and allow it to be retracted to one side by the assistant. When the vessel has been exposed, a point is selected a little more than an inch above the inguinal ligament (Poupart's) for the application of the ligature. The sheath, which at this point is thin, is opened in the usual manner, and the aneurysm needle passed from the medial side, care being taken to avoid the vein. The ligature is tied, the ends cut short, and the parietal wound closed. It is advisable, in closing the external wound, to unite the lower border of the internal oblique muscle to the upper portion of the inguinal ligament.

This operation is a modification of that known as " Cooper's operation." Abernethy employed a more vertical incision, which was also placed at a higher level (Fig. 370, *b*).

Collateral circulation.—(*a*) The superior epigastric artery and the abdominal branches of the lower intercostal and the lumbar arteries with the inferior epigastric, which is given off from the external iliac artery below the point of ligature ; (*b*) the lower lumbar arteries (anterior branches) and the iliac branch of the ilio-lumbar artery with the deep circumflex iliac artery, a branch of the external iliac ; (*c*) the inferior gluteal artery, with the other arteries which enter into the crucial anastomosis ; (*d*) the deep branches of the superior gluteal artery with the external circumflex of the thigh and the deep circumflex iliac in the region of the anterior superior iliac spine ; (*e*) perineal branches of the internal pudendal artery with similar branches from the external pudendal, a branch of the femoral ; (*f*) pubic branches of obturator artery with pubic branches of inferior epigastric.

The inferior epigastric artery (deep epigastric).—The inferior epigastric artery is a branch of the external iliac given off immediately above the inguinal ligament.

Its course is marked out by taking a line from immediately to the medial side of the central point of the inguinal ligament (Poupart's) to immediately lateral to the umbilicus.

Position.—As for the external iliac artery.

Operation.—An incision 2 inches long, at right angles to the line of the vessel, is made, so that the centre of the incision corresponds to the point where the line of the artery crosses the linea semilunaris (Fig. 372, *a*). The incision is deepened, and the fascial aponeurosis of the external oblique, and the falx aponeurotica formed by the union of the internal oblique and the transversus abdominis, are divided in order, when the fascia transversalis is exposed. The outer border of the rectus abdominis is then drawn inwards with a retractor, and the fascia transversalis divided, if requisite, in the line of the wound. The inferior epigastric artery is then exposed lying upon the peritoneum and in the extraperitoneal tissue accompanied by two venæ comites. The artery is separated from its accompanying veins, and a ligature passed from the medial side.

The deep circumflex iliac artery.—This vessel is a branch of the external iliac, given off at about the same level as the inferior epigastric artery.

Its course is behind and very slightly above the lateral half of the inguinal ligament (Poupart's), where it lies upon the iliac fascia, which separates it from the iliacus muscle. At the anterior superior spine of the ilium it pierces the fascia transversalis, and runs between the internal oblique and transversus muscles close to their attachments to the crest of the ilium. The lateral cutaneous (external cutaneous) nerve of the thigh lies behind the vessel.

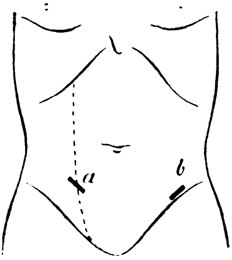

Fig. 372.—Position of skin incision in ligature of—
a. Inferior epigastric artery.
b. Deep circumflex iliac artery.

Position.—As for the external iliac artery.

Operation.—An incision 2 inches long is made parallel with and slightly above the lateral half of the inguinal ligament (Fig. 372, *b*). This divides the fascial layer, the aponeurosis of the external oblique, the origin of the lowest fibres of the internal oblique, the transversus in the lateral two-thirds of the wound, and finally the fascia transversalis, when the vessel is exposed lying upon the iliac fascia, and accompanied in this part of its course by two venæ comites. The needle is passed from either side, care being taken not to include the lateral cutaneous (external cutaneous) nerve of the thigh. A knowledge of the course and relations of the deep circumflex iliac artery is important, as in this region a psoas abscess is often opened.

The femoral artery (common and superficial femoral).—The femoral artery commences opposite the inguinal ligament (Poupart's), where it is continuous with the external iliac, and terminates below at the junction of the middle and distal thirds of the thigh at an aperture in the adductor magnus muscle, where it passes into the popliteal artery.

Its course is marked out by placing the limb in a position of abduction, external rotation, and slight flexion, and then drawing a line from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle of the femur. The proximal two-thirds of this line represents the course of the vessel, the remainder the femoral in the adductor canal. The relations of the vessel in the different parts of its course are shown in Figs. 374 and 376.

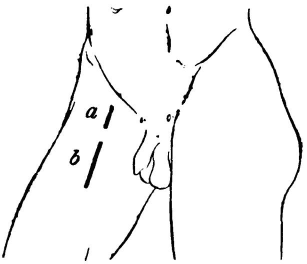

FIG. 373.—Ligature of femoral artery. Position of limb, and lines of external incision.

a. Femoral at upper part of thigh.
b. Femoral at apex of Scarpa's triangle.

About 1 to 2 inches below the inguinal ligament (Poupart's) the femoral (common femoral) artery gives off the deep femoral branch. The parts of the artery to which a ligature may be applied are the upper part of the femoral (common femoral), the femoral (superficial femoral) in the femoral (Scarpa's) triangle, the femoral (superficial femoral) in the adductor canal (Hunter's), and the profunda femoris.

Ligature of the femoral artery (common femoral artery).—This vessel lies immediately under the fascia lata, within the femoral sheath, having the psoas muscle behind, the femoral vein on the medial side, and the femoral nerve (anterior crural), and a few fibres of the psoas muscle on the lateral side.

Position.—The patient is placed in the dorsal position, with the thigh slightly flexed, abducted, and rotated outwards. The surgeon stands upon the outer side of the limb, and the chief assistant on the opposite side.

Operation.—An incision about 2 or 2½ inches in length is made in the line of the artery, commencing above immediately below the inguinal ligament (Poupart's) (Fig. 373, *a*). The skin, superficial fascia, and the deep fascia are divided, and the margins of the wound held aside with retractors, when the anterior layer of the femoral sheath will be exposed, the femoral nerve (anterior crural) lying upon its lateral side separated from the artery by a portion of the tendon of the psoas magnus muscle. The femoral (crural) branch of the genito-femoral (genito-crural) nerve may be met with, lying upon or within the sheath of the vessel. The artery is situated in the lateral compartment of the femoral sheath, and lies in close relation with the corresponding vein, which is placed medial to the artery and separated from it by a septum of connective tissue. The sheath is opened somewhat on the lateral side, so as to avoid injuring the vein, which may overlap it, and the needle is passed from the medial side. When the ligature has been applied the wound is closed in the usual manner.

Collateral circulation.—(*a*) Deep circumflex iliac with the ascending branch of the lateral circumflex of the thigh.

(*b*) Obturator with the medial circumflex of the thigh.

(*c*) Inferior gluteal (sciatic) with the other vessels taking part in the crucial anastomosis.

(*d*) Branches of the internal pudendal artery with superficial pubic branches of the (common) femoral, when these are given off below the point of application of the ligature. In all cases, where possible, ligature of the external iliac is to be preferred to ligature of the femoral.

Ligature of the femoral (superficial) artery in the lower part of the femoral triangle (Scarpa's).—*Position.*—The position of the patient and of the operator is the same as in ligature of the common femoral.

Operation.—An incision 3 to 3½ inches long is made in the line of the artery, and is so placed that the proximal two-thirds of the wound are situated in the distal part of the proximal third of the thigh, and the distal third of the wound in the proximal portion of the middle third of the thigh (Fig. 373, *b*). The vessel is ligatured at the apex of the femoral triangle (Scarpa's). The superficial fascia is divided, care being taken to avoid injury to tributaries of the large saphena vein, which may cross the line of the artery in this portion of the thigh; if, however, they cannot be drawn aside, two ligatures are applied, and the vessel divided between them. The deep fascia is then incised, when the sartorius muscle will be visible, its fibres crossing obliquely from above distally and medially. The medial border of the muscle is defined, and the entire muscle drawn laterally, by which means the anterior aspect of the sheath is exposed. The vein lies behind and to the medial side of the artery, whilst the medial (internal) cutaneous nerve and the medial branch of the intermediate (middle) cutaneous nerve lie anteriorly, and the long saphena nerve laterally. The sheath of the artery is opened, and the needle passed from the medial side, care being taken to keep the point of the needle against the wall of the vessel, and so avoid enclosure of any of the adjacent structures. When the ligature has been tied the ends are cut short, the sartorius

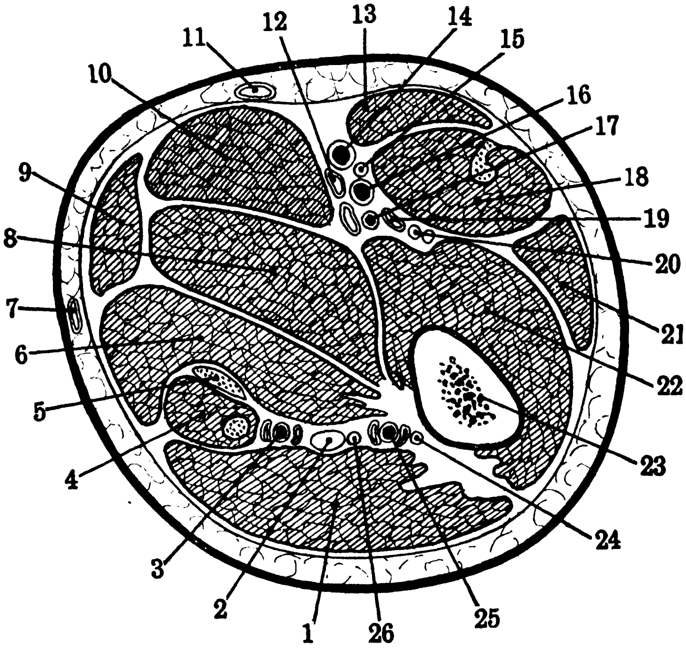

Fig. 374.—Transverse section through middle portion of proximal third of left thigh.

1. Glutæus maximus
2. Sciatic nerve.
3. Branches of inferior gluteal vessels (sciatic).
4. Semitendinosus.
5. Semimembranosus.
6. Adductor magnus.
7. Tributary of saphena vein.
8. Adductor brevis.
9. Gracilis.
10. Adductor longus.
11. Large saphena vein.
12. Femoral vein.
13. Sartorius.
14. Femoral artery.
15. Large saphena nerve.
16. Profunda femoral artery.
17. Medial circumflex artery of the thigh.
18. Rectus femoris.
19. Femoral vein.
20. Femoral nerve (anterior crural).
21. Tensor fasciæ latæ.
22. Vastus medialis (crureus).
23. Femur.
24. Inferior gluteal nerve.
25. Branches of gluteal vessels.
26. Posterior cutaneous nerve of thigh (small sciatic).

allowed to return to its former position, and the external wound closed.

Collateral circulation.—

(*a*) Descending branches of the lateral circumflex of the thigh with muscular branches of the femoral, the arteria suprema genu (anastomotica magna) and the superior lateral articular branches of the popliteal.

(*b*) The perforating branches of the profunda femoris with muscular branches of the femoral, superior muscular branches of the popliteal, and the superior articular branches of the same vessel.

Ligature of the femoral artery in the adductor canal (Hunter's).—

Position.—The same as for ligature of the common femoral, the surgeon standing on the outer side of the middle third of the thigh.

Operation.—An incision from 3 to 4 inches long is made in the line of the artery in the middle third of the thigh, the central point of the incision being opposite the mid-point of the thigh (Fig. 375, *a*). The superficial fascia is divided, and if the large saphena vein is seen it is drawn medially with a retractor. The deep fascia is next incised, and underneath it the sartorius will be exposed, the fibres running from above distally and medially. The lateral border of this muscle is then defined, and the entire structure drawn medially, when the aponeurosis which forms the roof of the canal will be exposed. In order to make this more distinct, it may be advisable to abduct the thigh more fully. The aponeurosis is incised in the line of the incision, and the artery with a thin sheath laid bare. In front of the vessel the large saphena nerve will be visible, on the lateral side the nerve to the vastus medialis and behind the corresponding vein, whilst surrounding the artery are branches of the sympathetic and the deep lymph vessels coming up from the popliteal space. The surface of the artery is bared in the usual manner, and the

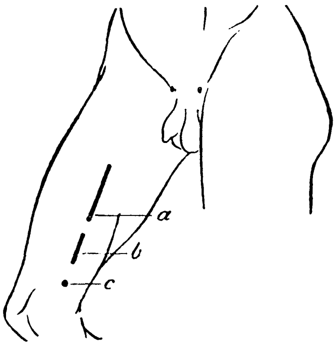

FIG. 375.—Position of limb and lines of incision for ligature of femoral artery in the adductor canal, and the popliteal artery in the proximal portion of the popliteal space.

a. Incision for femoral artery.
b. Incision for popliteal artery
c. Adductor tubercle of femur.

needle passed from either the medial or the lateral side, care being taken not to include a nerve in the ligature, or pierce the vein with the needle.

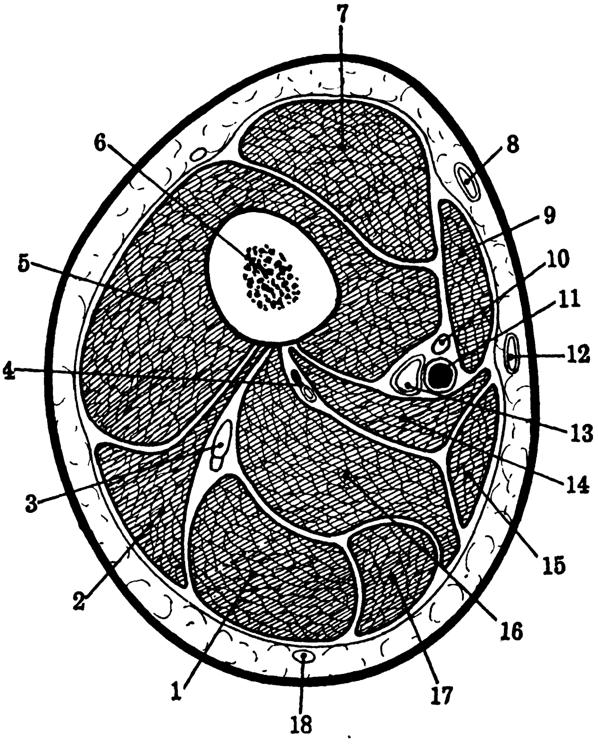

FIG. 376.—Transverse section of middle third of right thigh (through Hunter's canal).

1. Semimembranosus.
2. Biceps femoris.
3. Sciatic nerve.
4. Profunda femoris vessels.
5. Quadriceps extensor femoris.
6. Femur.
7. Rectus femoris.
8. Large saphena vein.
9. Sartorius.
10. Large saphena nerve.
11. Femoral artery.
12. Tributary of large saphena vein.
13. Femoral vein.
14. Adductor longus.
15. Gracilis.
16. Adductor magnus.
17. Semitendinosus.
18. Posterior cutaneous nerve of thigh (small sciatic).

Collateral circulation.—The circulation is re-established along the same channels as have been enumerated in connection with ligature of the artery in the femoral triangle (Scarpa's).

The popliteal artery.—The popliteal artery commences at the aperture in the adductor magnus, runs at first slightly laterally but chiefly distally to the middle of the space, when it takes a vertical direction to the distal border of the popliteus muscle, at which point it terminates by dividing into the anterior and posterior tibial arteries.

In its course downwards it lies behind the bare triangular area on the posterior aspect of the lower part of the femur, then upon the oblique popliteal ligament (Winslow's), and finally upon the fascia which covers the popliteus. The vein lies in close relation to the artery, at first being on the lateral side and superficial, then superficial, and finally medial. The popliteal (internal) nerve is more superficial, but, like the vein, crosses from the lateral to the medial side during its course downwards. That branch of the obturator nerve which goes to the knee-joint lies upon the upper portion of the artery, between it and the vein.

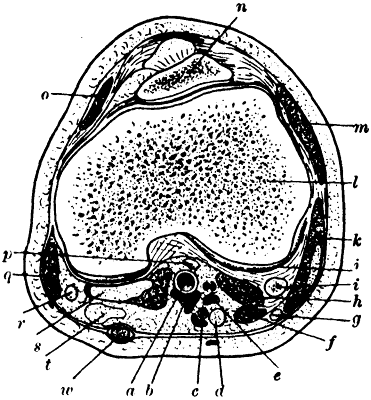

FIG. 377.—Transverse section through the right thigh, at the level of the proximal part of the popliteal space.

a. Popliteal artery.
b. Popliteal vein.
c. Sural vessels.
d. Tibial nerve (internal popliteal).
e. Vessels to gastrocnemius.
f. Plantaris..
g. Peroneal nerve (external popliteal).
h. Gastrocnemius.
i. Sesamoid bone.
j. Synovial membrane of knee.
k. Biceps.
l. Femur.
m. Vastus lateralis.
n. Patella.
o. Vastus medialis.
p. Lymph gland.
q. Sartorius.
r. Internal lateral ligament.
s. Gastrocnemius.
t. Semimembranosus.
w. Semitendinosus.

The popliteal artery may be ligatured in the proximal part of its course as it lies behind the femur, or in the distal part where it is in relation with the fascia covering the popliteus.

Ligature of the popliteal artery in the proximal part of the popliteal space.—*Position.*—The limb is placed in a position similar to that for ligature of the femoral artery, but is more flexed and rotated outwards.

Operation.—The adductor tubercle is defined, and passing upwards from it can be felt the tendon of the adductor magnus. An incision is made, commencing below ½ inch above the adductor tubercle, and extending upwards for 3½ inches along the posterior border of the tendon (Fig. 375, *b*). The skin, superficial fascia containing branches of the medial (internal) cutaneous nerve, and the deep fascia, are divided in the line of the incision; the nerves and the large saphena vein, if seen, being drawn to the inner side. The anterior border of the sartorius muscle is then seen, and also the tendon of the adductor magnus. The sartorius is retracted backwards, and the adductor tendon forwards and to the lateral side, when the tendon of the semimembranosus will be exposed. This is drawn medially and backwards, and on separating the fatty tissue the artery will be found lying close to the bone. It is separated from the vein, which here lies posterior and external to the artery, and the needle is passed from the vein, care being taken not to include the geniculate branch of the obturator nerve.

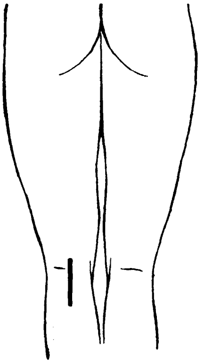

FIG. 378.—Ligature of popliteal artery in distal part of popliteal space. Position of the skin incision.

Collateral circulation.—(*a*) The superior lateral articular arteries, the arteria suprema genu (anastomotica magna), the descending branch of the lateral circumflex, and the lowest muscular branches of the profunda femoris, communicate with the inferior articular arteries and the recurrent branches of the anterior tibial.

(*b*) The articular branches of the arteria suprema genu and lateral circumflex with the azygos branch of the popliteal.

Ligature of the popliteal artery in the distal part of the popliteal space.—*Position.*—The patient is placed in a semi-prone position, and the limb fully extended. The surgeon stands on the outer side of the limb which is to be operated upon, and the assistant on the opposite side.

Operation.—An incision is made in the middle line of the popliteal space, 3 to 4 inches in length, commencing immediately below the central point of the space, and extending distally in the line of the artery (Fig. 378). The skin is divided, and then the superficial fascia, in which will be seen the small saphena vein and the posterior cutaneous nerve of the thigh (small sciatic). These structures are retracted to the outer side, and then the deep fascia is divided, when the two heads of the gastrocnemius will be exposed. These are separated without injuring the large arteries and nerves which go to them, and the small saphena vein followed till it joins the popliteal vein. The popliteal nerve is generally seen first, then the vein, and, somewhat to the lateral side and at a slightly deeper level, the artery. The popliteal nerve (internal popliteal) and vein are drawn towards the medial side, and the needle passed from these structures. The performance of the deep dissection may be facilitated by flexing the knee slightly, so as to relax the gastrocnemius.

Collateral circulation.—Similar to that which is established after ligature of the first part of the artery.

The posterior tibial artery.—The course of the posterior tibial artery is represented by drawing a line from the central point of the popliteal space to a point at the junction of the medial and intermediate thirds of a line drawn from the tip of the medial malleolus to the medial side of the prominence of the heel. The artery commences at a point in the leg ½ inch below the distal border of the tubercle of the tibia, and in the first part of its course it lies a little medial to the above line.

The proximal part of the artery is deeply placed in the calf, lying underneath the soleus and gastrocnemius muscles, and the deep transverse fascia of the leg which separates the superficial group of muscles from the deep (Fig. 380). In the distal third of the leg it is more superficial, and lies immediately below the deep fascial septum separating the superficial and deep layers of muscles. In its course downwards it lies upon the tibialis posterior, the flexor digitorum longus, the posterior surface of the tibia, and the ligaments of the ankle-joint. The tibial (posterior) nerve lies on the lateral side of the artery, except for a short distance at its commencement. The artery is accompanied by two venæ comites.

A ligature may be applied to the posterior tibial artery in the middle third of the leg, in the distal third of the leg, or at the ankle-joint.

Ligature of the posterior tibial artery in the middle third of the leg.—*Position.*—The patient lies in the dorsal position, the limb to be operated upon is flexed at the knee, and the leg lies upon its outer side. The surgeon stands on the outer side of the limb and leans over, the assistant being placed opposite him.

Operation.—The postero-medial border of the tibia is defined, and an incision 3 to 4 inches long made parallel to this border, but about ½ inch behind it, in the middle third of the leg (Fig. 379, *a*). The skin and superficial fascia are divided, and if the large saphena nerve and vein are seen they are retracted to the medial side or backwards. The deep fascia is then incised, and underneath it the soleus, where it is attached to the medial border of the tibia, made out. In this part of the operation, in a muscular subject, the edge of the gastrocnemius may become visible, in which case it is drawn backwards. When the soleus has been bared it is divided for the entire length of the incision, immediately beyond its attachment to the tibia; and when this has been done the deep transverse fascia which separates the superficial muscles from the deep is divided in the line of the original incision. On following inwards the deep aspect of this fascia for a short distance, the artery will be seen lying upon its deep surface, between it and the tibialis posterior. On each side of the artery there is a vena comes; the tibial nerve lies on the outer side. Care must be taken not to divide the flexor digitorum longus along with the soleus, since if this is done it is possible to mistake the interosseous mem-

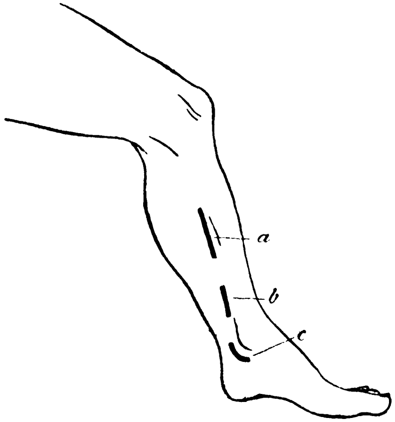

FIG. 379.—Position of limb and lines of incision for exposure of the posterior tibial artery in the middle and distal thirds of the leg, and at the ankle behind the medial malleolus.

a. Middle third. | *b*. Distal third.
c. At ankle.

brane for the deep transverse fascia, and tie the anterior tibial artery instead of the posterior. The relations of the artery at the point of ligature are shown in Fig. 380.

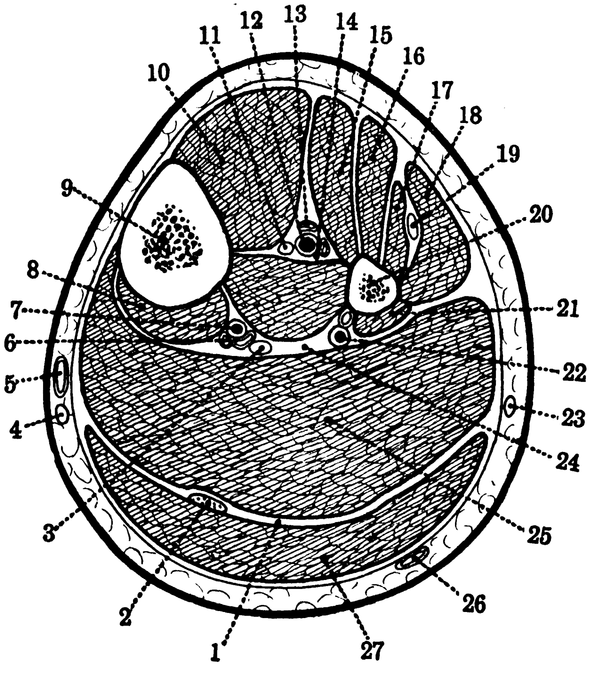

FIG. 380.—Transverse section of leg. Lower portion of middle third.

1. Fascia between soleus and gastrocnemius.
2. Plantaris.
3. Posterior tibial nerve.
4. Large saphena nerve.
5. Large saphena vein.
6. Posterior tibial vein.
7. Posterior tibial artery.
8. Flexor digitorum longus.
9. Tibia.
10. Tibialis anterior.
11. Deep peronæal nerve (anterior tibial).
12. Anterior tibial artery.
13. Anterior tibial vein.
14. Interosseous membrane.
15. Extensor hallucis longus.
16. Extensor digitorum longus.
17. Peronæus brevis.
18. Peronæus longus.
19. Peronæal nerve (musculo-cutaneous)
20. Fibula.
21. Flexor hallucis longus.
22. Peronæal artery and vein.
23. Small saphena nerve.
24. Deep transverse fascia.
25. Soleus.
26. Small saphena vein.
27. Gastrocnemius.

Ligature of the posterior tibial artery in the distal third of the leg.—*Position.*—The positions of the patient, surgeon, and assistant are similar to those in ligature of the vessel in the middle third.

Operation.—An incision 2 or 2½ inches long is made along the line of the vessel in the distal third of the leg (Fig. 379, *b*). This divides the skin, superficial fascia, and the deep fascia, which at the lower part is somewhat thickened, owing to the transverse fibres being more developed, where it forms the medial annular ligament of the ankle-joint. The incision lies between the medial border of the tibia and the medial margin of the tendo calcaneous. Underneath the deep fascia the artery is found lying upon the flexor digitorum longus, surrounded by its venæ comites, and having the nerve on the lateral side. The needle is passed from the lateral side.

Ligature of the posterior tibial artery behind the medial malleolus.—*Position.*—As for ligature of the vessel in the middle third.

Operation.—A curved incision is made in the space between the medial malleolus and the heel, the convexity being towards the prominence of the calcaneous (Fig. 379, *c.*). This incision is about 2 inches in length, and in direction corresponds to the curve of the medial malleolus, but is ⅔ inch behind it. The skin, superficial fascia, and deep fascia, which in this situation is very much thickened to form the medial annular ligament, are divided in succession, when the artery will be found lying on the medial side of the ankle-joint, having a vena comes on the medial side, and a second vena comes and the posterior tibial nerve on the lateral side. The vessel is separated from its venæ comites, and the needle passed from the nerve. If the venæ comites are very closely connected with the vessel they may be ligatured as well.

Collateral circulation.—When the posterior tibial artery has been ligatured, the following communicating channels become dilated :—

(*a*) Branches of the peronæal artery with branches of the posterior tibial which are given off below the point of ligature, and with the lateral plantar by the calcaneal and malleolar branches.

(*b*) Medial malleolar branches of the anterior tibial, with similar branches of the posterior tibial.

(*c*) The dorsalis pedis artery and its branches, with the medial and lateral plantar arteries.

The peronæal artery.—This vessel is a branch given off from the posterior tibial, 1 inch below the distal border of the tubercle of the tibia.

It runs distally, lying behind the fibula, and covered by the flexor hallucis longus muscle. In the distal part of the leg it becomes much smaller, and ends by dividing into two terminal branches, the anterior and posterior peronæal branches.

A ligature may be applied to the vessel in the middle of the calf.

Position.—The patient is placed in a semiprone position, lying upon the side which is not to be operated upon. The leg is slightly flexed at the knee, and the limb lies with the external aspect before the operator.

Operation.—The postero-lateral border of the fibula is defined with the fingers, and an incision 3 inches long made in the middle of the leg over this border of the bone (Fig. 381). When the skin and fasciæ have been divided, the lateral border of the soleus muscle will be exposed. This muscle is retracted, and, if necessary, its attachment to the fibula in the proximal part of the wound cut through. By this means the origin of the flexor hallucis longus from the fibula is laid bare. This is separated from the bone until the artery is exposed, lying in a canal of fibrous tissue between the medial part of the flexor hallucis longus and the tibialis posterior. The needle may be passed from either side.

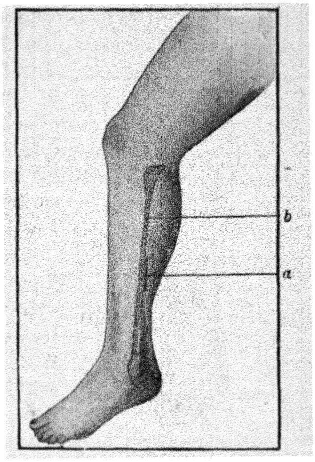

FIG. 381.—Ligature of peroneal artery.

a. Position of external incision.
b. Fibula.

The anterior tibial artery.—This vessel commences at the distal border of the popliteus muscle, and terminates in front of the ankle-joint, where it becomes the dorsalis pedis.

Its course is marked out by drawing a line from a point which is half-way between the prominent portion of the lateral condyle of the tibia and the head of the fibula, to a point midway between the two malleoli.

In its course distally it lies upon the interosseous membrane for the proximal two-thirds, and on the tibia and the ankle-joint below this level. It lies in relation with the tibialis anterior on the medial side, and on the lateral side it has the extensor digitorum longus at first, and lower down is separated from this muscle by the extensor hallucis longus. The tendon of the latter crosses the artery below. The deep peroneal (anterior tibial) nerve lies chiefly on the lateral side, although for a short distance it may lie in front. The artery is accompanied by two venæ comites.

The anterior tibial artery may be ligatured at the proximal, middle, or distal thirds of the leg.

Ligature of the anterior tibial artery in the proximal third. —*Position.*—The patient is placed in the dorsal position, the leg being rotated inwards with the foot fully extended. The surgeon stands on the outer side of the limb, and the assistant on the opposite side.

Operation.—An incision 3 or 4 inches long is made in the line of the artery, commencing proximally at the level of the tubercle of the tibia. The skin, superficial and deep fascia, are divided, and the interval between the tibialis anterior and the extensor digitorum longus defined. This interval can usually be felt by the finger as a slight depression in the line of the incision. At this stage the foot is flexed, so as to allow these muscles to be separated with retractors. Upon the anterior surface of the interosseous membrane, and a short distance to the lateral side of the tibia, the artery will be found, having a vena comes on each side and the nerve on the lateral side. The vessel is separated from the nerve, and, if possible, from the venæ comites, and the needle passed from the lateral side.

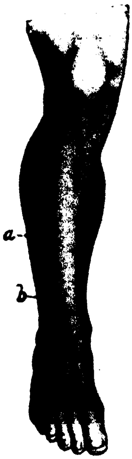

FIG. 382.—Position of limb and lines of skin incisions in ligature of anterior tibial artery.

a. Middle third.
b. Distal third.

Ligature of the anterior tibial artery in the middle third.—*Position.*—This is the same as for ligature in the upper third.

Operation.—An incision 3 inches long, whose central point corresponds to the mid-point of the leg, is made in the line of the artery about two fingers-breadth behind the anterior border of the tibia (Fig. 382, *a*). This incision divides the skin, superficial and deep fasciæ, and exposes the muscles. An interval between the tibialis anterior and the extensor digitorum longus is defined (it can generally be felt with the finger, or may appear as a slight depression of a somewhat yellowish tint), and these muscles are separated and retracted. The extensor hallucis longus is next met with, overlapping the vessel from the lateral side; it in turn is pulled aside, and the artery will be exposed. In the middle third of the leg the anterior tibial nerve often lies in front of the vessel, in which case it is retracted to the lateral side. The needle is passed from the nerve. The venæ comites are usually included within the ligature, owing to the difficulty of separating them from the artery.

Ligature of the anterior tibial artery in the distal third.—*Position.*—As for ligature of the vessel in the proximal third, though the foot is not rotated to the same extent.

Operation.—An incision 2 to 2½ inches long is made in the line of the artery immediately above the ankle (Fig. 382, *b*). This divides the skin, superficial fascia, and deep fascia, which in this situation is considerably thickened to form the transverse portion of the anterior annular ligament of the ankle. Underneath the deep fascia the tendons of the tibialis anterior and the extensor hallucis longus are defined, the former being surrounded with a synovial sheath, and lying in a separate compartment beneath the annular ligament. The tendon of the extensor hallucis longus is drawn to the lateral side, when the artery will be exposed as it lies upon the tibia. The nerve lies on the lateral side. The nerve is drawn aside, and the needle passed from the lateral side.

Collateral circulation.—(*a*) The lateral malleolar and inferior muscular branches of the anterior tibial, with the lateral malleolar and calcaneal branches of the peronæal artery.

(*b*) The medial malleolar branch of the anterior tibial, with a similar branch from the posterior tibial.

(*c*) Muscular, tarsal, and metatarsal branches of the dorsalis pedis, with the terminal branches of the anterior peronæal.

(*d*) The dorsalis pedis, with the medial and lateral plantar arteries.

The dorsalis pedis artery.—The dorsalis pedis artery is the continuation of the anterior tibial, and extends from the ankle to the sole, where it joins the lateral plantar.

Its course is marked out by taking a line from the central point between the two malleoli to the base of the first intermetatarsal space.

It lies upon the dorsal surface of the tarsus, between the tendon of the extensor hallucis longus on the medial side, and the most medial tendon of the extensor digitorum longus on the outer side.

Position.—The patient lies in the dorsal position, with the sole resting upon the table; the surgeon stands on the outer side of the limb. One assistant holds the foot in a state of complete extension, and the other stands opposite the surgeon and retracts the margins of the wound.

Operation.—An incision from 1 to 2 inches long is made on the dorsum of the foot in the line of the vessel, commencing about 1 inch below the ankle-joint at the distal margin of the inferior portion of the anterior annular ligament (Fig. 383). The incision is situated between the tendons of the extensor hallucis longus and the extensor digitorum longus, and divides the skin and superficial and deep fasciæ, when the artery will be exposed lying upon the bone and surrounded by a variable quantity of fatty tissue. The most medial tendon of the extensor digitorum brevis will usually be seen crossing the artery in the distal part of the incision, and should be retracted distally and laterally. The nerve lies laterally and the needle is passed from the lateral side.

Collateral circulation.—This is established through the communications of the terminal portion of the vessel with the deep plantar arch.

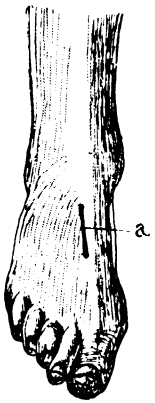

FIG. 383.—Ligature of the dorsalis pedis artery.

a. Position of skin incision.

The hypogastric artery (Internal iliac, O.T.).—The hypogastric trunk extends from the upper border of the sacro-iliac synchondrosis to the upper border of the great sacro-sciatic foramen. It is one of the two terminal divisions of the common iliac artery.

It lies upon the anterior aspect of the lateral mass of the sacrum, from which it is separated by the lumbo-sacral cord. The corresponding vein lies to the medial side and behind, whilst laterally it has the medial margin of the psoas magnus muscle. The ureter lies along the anterior aspect of the hypogastric artery, and the peritoneum and intestines cover it in front.

Position.—As for ligature of the common iliac artery.

Operation.—An incision about 4 inches long is made in the linea alba, commencing a short distance above the pubic symphysis. The peritoneal cavity is opened, and the intestines and great omentum pushed aside and held out of the way by flat sponges and large retractors or by the hands of an assistant. The point of division of the common iliac is defined, and from this the hypogastric artery is traced as it lies upon the front of the sacrum. The peritoneum over it is divided freely, and the vessel separated from the ureter and the sympathetic plexus which surrounds it. The aneurysm needle is passed from the medial side so as to avoid injury to the vein, which is usually of large size.

Collateral circulation—

(*a*) Ilio-lumbar with the deep circumflex iliac.

(*b*) The lateral sacral with the middle sacral and the lateral sacral of the opposite side.

(*c*) The glutæal with the deep circumflex iliac and the ascending branch of the lateral circumflex of the thigh.

(*d*) The internal pudendal and obturator arteries, with similar vessels of the opposite side.

(*e*) The obturator artery, with the medial circumflex of the thigh and the inferior gluteal.

(*f*) The hæmorrhoidal branch of the inferior mesenteric with the hæmorrhoidal branches of the internal iliac.

The inferior gluteal (sciatic, O.T.) and internal pudendal (internal pudic, O.T.) arteries.—Both these vessels are terminal branches of the anterior division of the hypogastric (internal iliac, O.T.), and are given off from this vessel as it lies upon the anterior surface of the piriformis muscle, just before the latter leaves the pelvis. They emerge from the pelvis through the great sacro-sciatic foramen at the lower border of the piriformis. The inferior gluteal artery is more superficial at the point of emergence, whilst the internal pudendal lies on the medial side.

The point where these vessels come out from the pelvis is marked on the surface by trisecting a line drawn from the posterior superior iliac spine to the lateral part of the ischial tuberosity; the junction of the middle and distal thirds of this line is the point required.

Position.—The patient is placed on the sound side in the semiprone position, with the legs hanging over the end of the table. The surgeon stands on the side to be operated upon, and the assistant on the opposite side.

Operation.—The point of emergence of the vessels is marked out, and then an incision 4 inches long, whose centre corresponds to the point of emergence, is made in the line of the fibres of the glutæus maximus (Fig. 384, *a*). The skin, superficial and deep fasciæ are divided; then the muscle is incised or its fasciculi separated for the entire length of the wound, and the margins well retracted till the piriformis is exposed at the bottom of the wound. The distal border of this muscle is defined and traced inwards to the sciatic foramen, when the artery will appear. When dividing the glutæus maximus, a large muscular branch of the inferior gluteal artery (sciatic) may be cut across, in which case it will serve as an easy guide to the main vessel if it is traced inwards. The internal pudendal artery lies upon the tip of the ischial spine, somewhat medial to the inferior gluteal artery, and at a slightly deeper level. In each case the artery is separated from the adjacent structures, and the needle passed from the medial side. In the case of the internal pudendal artery, care must be taken to avoid including within the ligature the pudendal nerve, which lies immediately medial to the vessel, and the nerve to the obturator internus, which lies to the lateral side of the artery.

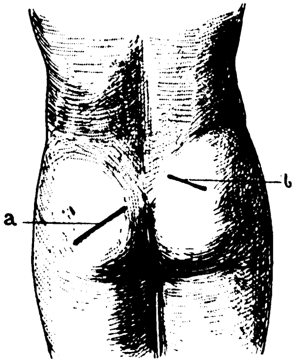

Fig. 384.—Ligature of the superior and inferior gluteal and internal pudendal arteries

a. Incision for inferior gluteal and internal pudendal.
b. Incision for superior gluteal.

The superior gluteal artery (gluteal).—This vessel is the terminal branch of the posterior division of the internal iliac. It passes out from the pelvis through the upper part of the great sacro-sciatic foramen at the upper border of the piriformis, and is accompanied by two venæ comites and the superior gluteal nerve. Just beyond its point of emergence it subdivides into superficial and deep portions, and on this account it is necessary to apply the ligature close to the margin of the foramen. The gluteal artery emerges from the pelvis at a point corresponding to the junction of the inner and middle thirds of a line joining the posterior superior iliac spine and the top of the great trochanter, the thigh being rotated inwards.

Position.—This is the same as for ligature of the sciatic artery.

Operation.—An incision from 3½ to 4½ inches long is made parallel with the fibres of the glutæus maximus, the centre of the incision corresponding to the point of emergence of the artery from the pelvis (Fig. 384, *b*). The skin, superficial fascia containing a number of cutaneous nerves, and deep fascia are divided, and the glutæus maximus exposed. The fasciculi of this muscle are separated until the fascia which lies between it and the glutæus medius and piriformis becomes visible. An interval between the two latter muscles is then sought for, and when found the muscles are separated along this line until the sacro-sciatic foramen is reached. The gluteal artery can then be felt against the bony margin of the foramen as a distinct rounded structure. Whilst separating the fibres of the glutæus maximus, a large muscular branch of the superior gluteal artery may become visible, in which case it is traced onwards until it joins the main trunk. When the position of the gluteal artery has been made out, the glutæus medius and piriformis are held well aside with retractors; the artery is separated from the superior gluteal nerve and the venæ comites, and then the needle is passed from the nerve.

SUTURE OF ARTERIES

Until quite recently repair of wounds in the large arteries has not proved to be a successful surgical operation, since the methods of suture adopted have allowed a roughened margin of blood vessel or portion of suture material to project towards the lumen of the vessel operated upon. This has induced the deposit of fibrin upon the roughened portion and so caused either thrombosis or embolism, or both. A method of suturing has now been devised by Dorrance which almost entirely avoids these complications. He uses very fine rounded needles with a spring eye, and very fine silk which has been impregnated with sterile vaseline. The form of suture is a " mattress suture " slightly modified, which is strengthened by a superimposed tier of continuous suture, the " mattress suture " passing through the entire thickness of the artery and the continuous suture through the muscular and fibrous coats. This method of suturing is available both for the closure of lateral wounds of arteries and for end-to-end approximation after a large vessel has been completely cut across. The principal object aimed at in the repair of an injured large artery, is re-establishment of the arterial blood channel and avoidance of gangrene of the limb beyond. Exposure of the injured artery can be effected, usually, by incision and dissection according to the methods described in connection with ligature of the corresponding artery in the earlier parts of the chapter.

Indications.—(*a*) Wounds of large arteries, caused by perforating or incised wounds, when the vessel is completely or partially severed. When the wound involves only a portion of the circumference of the vessel, lateral suture, either longitudinal (parallel to the course of the artery) or transverse, should be practised, and when the vessel is completely cut through end-to-end anastomosis of the severed extremities should be effected. If the cause of the injury has been some form of lacerating wound, such as those caused by the projectiles of firearms, it will usually be necessary either to pare the margins of the wound or to remove a small segment of the wounded vessel. The easiest cases to which the surgeon can apply arterial suture will be those accidental wounds caused during the performance of operations ; but some cases of stab wounds of large blood vessels, when pressure to arrest hæmorrhage has been promptly applied, offer considerable chances of success. Septic wounds and injuries of blood vessels are not suitable for the application of lateral or end-to-end arterial suture, and should only be treated by ligature.

(*b*) For the repair of a wound in the course of a large artery which has been made by the surgeon for the extraction from within of a non-septic thrombus or embolus.

(*c*) As part of the operation for reversal of the circulation of the blood in a limb which is suffering from impending gangrene owing to extensive blocking of the artery supplying it with blood. A number of operations have been carried out with this object, but up to the present time they have not been accompanied with success.

Instruments.—Rubber-covered clamps for temporarily arresting the circulation on the proximal and distal sides of the lesion, fine round needles with spring eyes, very fine silk impregnated with sterile vaseline.

Operation.—An incision is made along the course of the injured artery, if possible by enlarging in one or both directions the wound which has caused the damage, and the vessel exposed for a distance of two or three inches. The site of injury to the artery should occupy the centre of exposure. Rubber-covered clamps are next applied to the vessel at each extremity of the exposed segment, in such a manner that the circulation is controlled but no injury caused to the walls of the blood vessels. The best method of avoiding unnecessary damage is by carefully tightening the clamps until the flow of blood is just arrested. The region of the injury is carefully sponged dry and all fibrin and blood clot removed. The margins of the wound in the vessel are next everted in order to facilitate the approximation of nothing but intima during the process of suturing. The details of the introduction of the suture are shown in Figs. 385–387. When a longitudinal wound is being repaired, the needle, armed with a long suture of fine silk, is first made to pass through the outer and middle coats of the vessel about one-eighth of an inch beyond one extremity of the injury, then out again, the suture drawn through and tied, the end nearest to the needle being left long. The internal aspects of the artery on each side of the wound are approximated, and the needle passed from without inwards on one side of the solution of the continuity in the arterial wall and then from within outwards on the other side. Next it is again passed in a reverse direction but in a similar manner, thus making a " mattress " stitch. This method of suturing is continued for the entire length of the wound in the arterial wall, but after each third stitch the suture is carried backwards for the extent of the previous stitch in order to strengthen the line of approximation. During the insertion of this " mattress " suture the needle should be passed quite near the margins of the

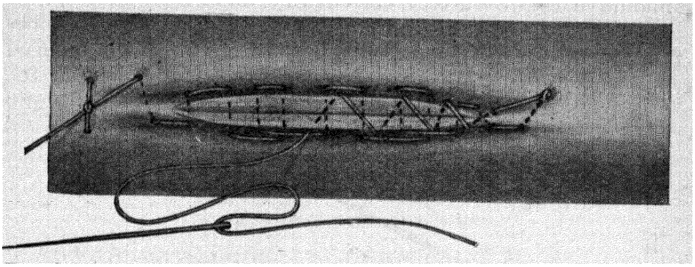

FIG. 385.—Arterial suture. (Dorrance.) The illustration shows a longitudinal wound in an artery in which a continuous " mattress " suture has been passed from one end of the injury to the other and a reduplication stitch has been inserted at every third loop.—After BURGHARD.

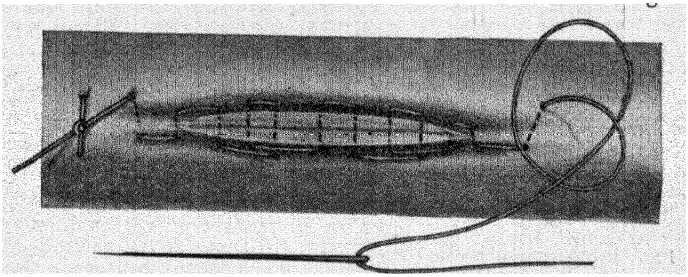

FIG. 386.—Arterial suture. (Dorrance.) The illustration shows the method of inserting a continuous suture of the superficial tier. The suture silk is passing in the reverse direction to that of the " mattress " suture, and only picks up the outer and middle coats of the vessel. When the extremity is reached the end of the continuous suture is knotted to the end left long at the commencement of the " mattress " suture.—After BURGHARD.

wound in the wall of the artery, but always through all the coats, including the intima. When the end of the breach in the arterial wall has been reached, the needle is passed through the outer and middle coats of the artery, one-eighth of an inch beyond, and the suture completed by tying a single knot. The line of approximation of the margins of the wound in the artery are again sponged and a continuous suture of fine silk inserted superficial to the "mattress" suture, the suture passing through the outer and middle coats of the injured part of the artery and picking up the margins between each loop of the "mattress" suture. When the end of the line of suturing is reached, the end of the suture is tied to the commencement of the original suture.

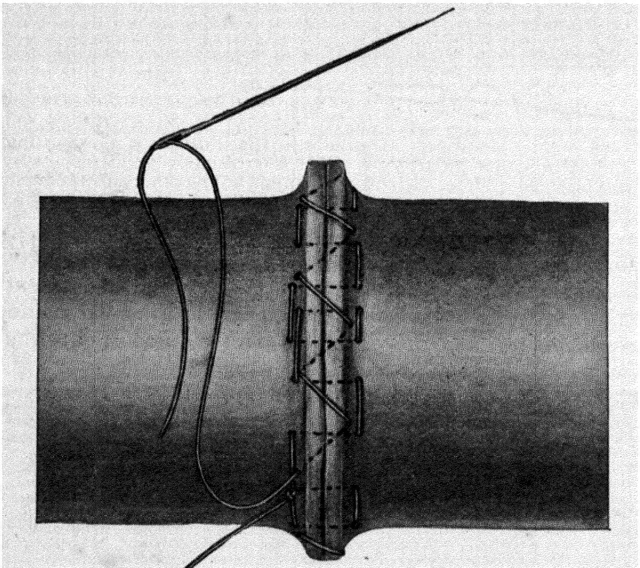

FIG. 387.—Arterial suture, end-to-end. (Dorrance.) The illustration shows the "mattress" suture inserted and the divided ends of the artery everted in the form of a flange.—After BURGHARD.

When the suturing has been completed, the ends are cut short and the rubber-covered clamps removed first on the distal and then on the proximal side. As the circulation is re-established, careful observation is made in order to ascertain that there is no leakage along the line of suture. Next, the field of operation is again sponged dry, and the region of the sutured artery covered over with deep fascia which is fixed by several points of interrupted suture. When it is necessary to perform end-to-end suture of an injured artery the details of suturing are similar to those just described. First, the ends of the divided vessel are pared if requisite and brought into close approximation, and the ends everted as the suturing proceeds, so as to ensure exact co-aptation of intima to intima. The method of inserting the sutures is shown in Fig. 387. The injury to the artery having been repaired by one of the above two methods, the external wound is closed by the insertion of interrupted sutures and dressings applied.

OPERATIONS FOR ANEURYSM

Endo-Aneurysmorrhaphy—Operation of Matas.—By the term endo-aneurysmorrhaphy is understood obliteration of the sac of an aneurysm by intra-saccular suturing. The originator of this method of treatment of aneurysm—Matas—founded his operation on the facts that an aneurysmal sac is lined with a layer of endothelium on its internal aspect, which is similar to and continuous with the endothelium lining the interior of the artery from which the aneurysm has taken its origin, and also that when two layers of endothelium are fixed in close approximation by sutures they will become adherent by plastic lymph and the space between them become obliterated.

There are three varieties of endo-aneurysmorrhaphy which may be practised. These are :—

(*a*) **Obliterative.**—When the entire cavity of the aneurysmal sac is obliterated by sutures after closure of the apertures of entrance and exit of the main artery in connection with which an aneurysm has developed. This operation is of greatest value in the treatment of fusiform aneurysms, the walls of which are thin, very hard, and destitute of elastic tissues.

(*b*) **Reconstructive.**—When a canal is fashioned from the sac of a fusiform aneurysm in such a manner, that a tube resembling the original vessel in size, shape and position is left connecting the lumen of the main artery at entrance to the lumen of the same vessel at exit, and the other portions of the sac are obliterated by sutures. This operation can be carried out in cases of fusiform aneurysm when the walls of the sac are lined with endothelium and are strong, firm and elastic.

(*c*) **Restorative.**—When the sac of an aneurysm is obliterated by suturing, and the aperture of communication between the aneurysmal sac and the lumen of the artery from which it has arisen closed in such a manner that the channel of the parent vessel is left. This operation is recommended in cases of saccular aneurysm.

Special instruments.—Round needles, straight and curved with spring eyes, fine silk impregnated with sterile vaseline, and chromicised catgut. Also arterial clamps, rubber tubing, and a suitable tourniquet when an aneurysm of a peripheral artery is to be treated.

Preliminary procedures.—It is necessary in all cases of endo-aneurysmorrhaphy that the circulation of blood in the aneurysmal sac and in the vessel leading to and from it should be effectively controlled. This can be done in the case of an aneurysm of the limbs by the application of an elastic tourniquet to the limb on the proximal side of the sac, and in the case of aneurysms of the arteries of the trunk or neck by the application of rubber-covered arterial clamps or temporary ligatures to the affected vessel proximal and distal to the affected segment, after the vessel has been exposed in the early stages of the operation.

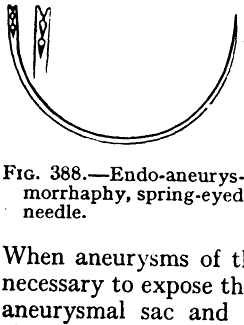

FIG. 388.—Endo-aneurysmorrhaphy, spring-eyed needle.

Operation.—After the circulation has been controlled by an elastic tourniquet in the case of an aneurysm of a peripheral artery, an incision is made over the swelling caused by the aneurysm, and the soft parts divided and retracted until the aneurysmal sac and the vessel from which it rises are exposed. When aneurysms of the trunk or neck are being treated, it is necessary to expose the parent vessel proximal and distal to the aneurysmal sac and to apply either rubber-covered arterial clamps or temporary ligatures in order to control the circulation. The details of exposure of the individual arteries have already been described in the earlier parts of this chapter, and to these the student is referred. When the aneurysm has been laid bare, the further procedures vary according to the variety of endo-aneurysmorrhaphy which it has been determined to carry out.

Obliterative endo-aneurysmorrhaphy.—The surface of the sac having been exposed in the bottom of the wound, the cavity is laid open by cutting with the scalpel from one end to the other, the incision commencing at a point just below where the main vessel opens into the sac, and terminating immediately above where it leaves it. The interior of the sac is then emptied of all blood and clot if present, and then the openings into it both of the main vessel and branches are securely closed by the insertion of sutures passed through all the coats of the vessel.

The details of the method of inserting these sutures are shown in Figs. 389, 390, and 391. The remaining portions of the aneurysmal sac are obliterated by the insertion of two or more tiers of buried sutures until no cavity remains. Finally, the external wound is closed by other sutures, a small drain being inserted if thought necessary on account of oozing. During this operation the walls of the sac of the aneurysm should not be dissected free from the adjacent tissues.

Reconstructive endo-aneurysmorrhaphy.—The aneurysmal sac is exposed, laid open, and a portion of red rubber tubing of a calibre slightly smaller than that of the main vessel taken and passed into the vessel on each side of the dilated portion. This will serve as a splint and assist in the introduction of the sutures. A series of interrupted sutures of fine silk are next inserted after the method depicted in Fig. 392, all being introduced before any are tied. Next, those nearest to the extremities are tied and cut short. The piece of rubber tubing is drawn out from the lumen of the artery and the remaining sutures tied and cut short. This completes the first tier, and effects the closure of the communication between the aneurysmal sac and that of the main vessel (Fig. 393). A second tier of suturing is introduced in the

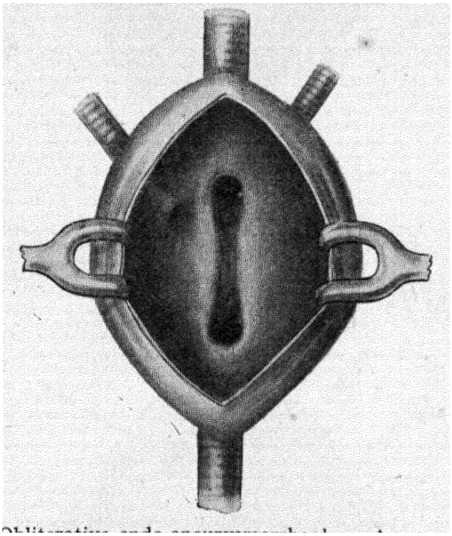

FIG. 389.—Obliterative endo-aneurysmorrhaphy. Aneurysmal sac laid open, showing openings of main vessel and of branches into its interior.

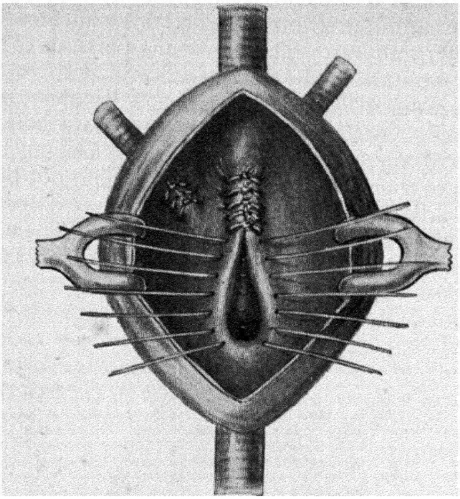

FIG. 390.—Obliterative endo-aneurysmorrhaphy. Aneurysmal sac laid open, with apertures of entrance of main vessel and of a branch closed by sutures and sutures inserted but not tied for closure of aperture of exit of main vessel.

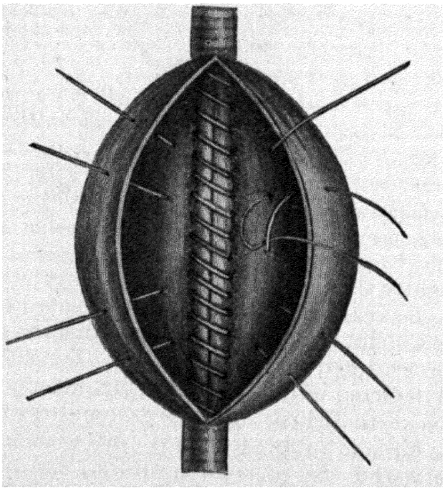

FIG. 391.—Obliterative endo-aneurysmorrhaphy. Aneurysmal sac laid open, showing apertures of entrance and exit of main vessel closed by a continuous suture and some of sutures introduced but not tied for obliteration of remainder of sac.

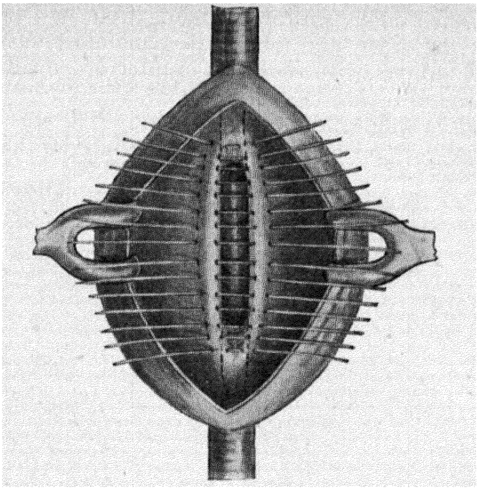

FIG. 392.—Reconstructive endo-aneurysmorrhaphy. Aneurysmal sac laid open and a tier of interrupted sutures inserted over red rubber tube but not tied.

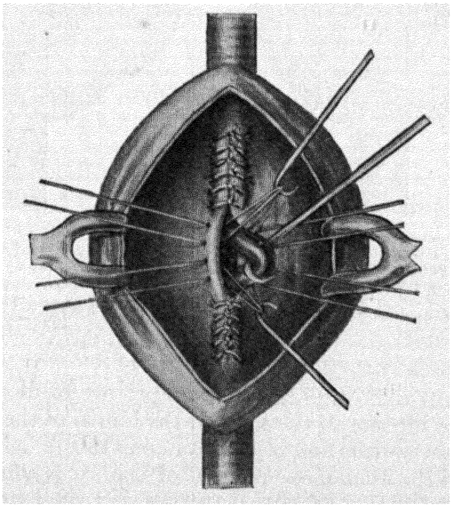

FIG. 393.—Reconstructive endo-aneurysmorrhaphy. Aneurysmal sac laid open, first tier of sutures introduced and those at each extremity tied and cut short. The red rubber tube is being drawn out.

form of a continuous suture extending from one extremity of the sac to the other, and finally the remaining portions of the sac are obliterated by further tiers of interrupted sutures. The external wound is then closed.

Restorative endo-aneurysmorrhaphy.—The aneurysmal sac is first exposed, laid open as before, the interior sponged dry, and all fibrin removed. Next, the aperture of communication between the interior of the sac and the lumen of the main vessel is closed by the insertion of a continuous suture, as in Fig. 394. Afterwards the remaining portion of the sac is obliterated by the insertion of tiers of buried sutures and the external wound closed.

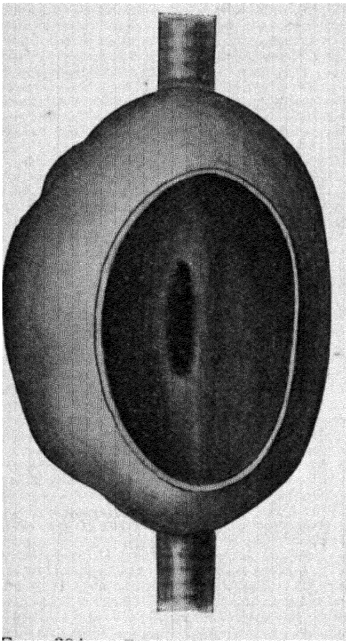

FIG. 394. — Restorative endo-aneurysmorrhaphy. Aneurysmal sac laid open.

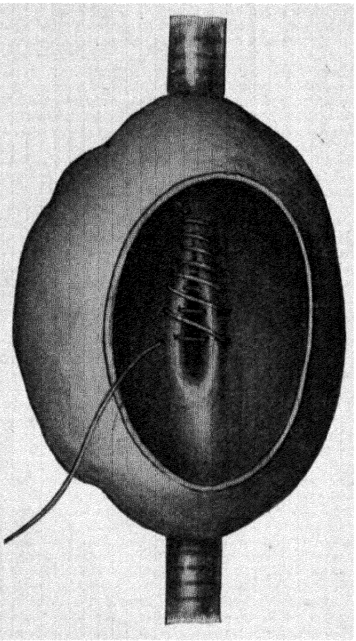

FIG. 395. — Restorative endo-aneurysmorrhaphy. Aneurysmal sac laid open, and communication with main vessel partially closed by insertion of a continuous suture.

Results.—The best results appear to be obtainable in those cases of aneurysm of the peripheral arteries which are submitted to obliterative endo-aneurysmorrhaphy. The reconstructive and restorative operations are especially applicable to aneurysms of the abdominal aorta or other large vessel in which it is not advisable to adopt the obliterative operation on account of the risks of gangrene in the parts distal to the site of operation owing to serious interference of the arterial blood supply.

Excision of the sac of an aneurysm.—The old operation of laying open followed by excision of the sac of an aneurysm, except in the case of small aneurysms of the peripheral arteries, has been almost entirely given up until recently, on account of the difficulties inherent in the operation due to adhesion of the sac to adjacent important structures, especially large veins, the occurrence of gangrene and the risks of serious hæmorrhage. A modification, however, has been practised during recent years in which the sac is first laid open by a vertical incision, the circulation being controlled by a tourniquet, the clots within the sac turned out by sponging, and the apertures of entrance and exit of the main vessel and any large branches defined. A black bougie of suitable size is passed through each opening, and two small cuts made with the scalpel through the sac wall close to each main opening. Through these openings a ligature is passed around the vessel close to the aneurysmal sac and tied, the bougie being first withdrawn. Other openings are treated in a similar manner, and then the external wound is closed. This operation is especially suitable for the treatment of aneurysms of peripheral arteries of traumatic origin and of recent development. Several weeks ought to be allowed to elapse between the date of reception of the injury, and the performance of the operation, in order to allow of establishment of an efficient collateral circulation.

As a result of the war, a large number of patients suffering from traumatic aneurysm have come under surgical observation. I have practised with considerable success in these cases, excision of the entire aneurysmal sac, preceded by ligature of the main vessel on the proximal and distal sides of the aneurysm and separate ligature of individual small vessels close to the sac. Previous to excision of the sac, the circulation is controlled by tourniquet if feasible, or temporary closure of artery on proximal side by arterial clip or ligature.

Varicose aneurysm.—A varicose aneurysm is a localised dilatation along the course of an abnormal communication between an artery and a vein. The most suitable operation for the relief of this condition is obliterative endo-aneurysmorrhaphy carried out as already described, great care being taken to close any collateral communication which may open into the sac in addition to the openings into the main artery on the one side and the vein on the other. When the circulation in the sac cannot be controlled satisfactorily by this procedure, the artery on the proximal and distal sides of the abnormal communication should be laid bare and ligatured in two places, and the sac also obliterated. The main vein should not be ligatured, but the aperture of communication with the sac closed by inserting a lateral suture.

Aneurysmal varix.—The site of communication between the artery and vein having been exactly defined, if possible a tourniquet is applied to the limb on the proximal side and the abnormal communication exposed by incision and dissection. Whent he communication has been laid bare it is cut across, and the communication with the artery closed by arterial suture in the manner already described. The communication with the vein is also sewn up by a lateral venous suture and the external wound closed.

CHAPTER XXIV

OPERATIONS UPON THE VEINS

EXPOSURE AND LIGATURE OF VEINS.

INTRA-VENOUS INJECTION OF SALINE FLUIDS AND OTHER SUBSTANCES.

TRANSFUSION OF BLOOD.

General considerations.—The remarks which were made under this heading in the previous chapter, in connection with the arteries, apply for the most part to the veins.

The instruments which are necessary are the same as for the ligature of an artery.

The jugular vein.—This vein is the chief vessel by which blood is returned from the interior of the cranium to the general circulation. It commences at the base of the skull at the lower border of the jugular foramen, by the union of the inferior petrosal and sigmoid sinuses as they emerge from the cranial cavity. It passes down the neck, lying in the carotid sheath of the deep cervical fascia, on the lateral side of and posterior to the internal carotid above the level of the thyroid cartilage, and below this level on the lateral side of the common carotid. Behind the outer part of the sterno-clavicular articulation it joins the subclavian vein of the corresponding side, the two together forming the innominate vein.

The course of the vein is marked out on the surface, after placing the patient in the dorsal position with the head turned towards the opposite side by drawing a line from the lower border of the external auditory meatus above to the outer part of the sterno-clavicular articulation below.

Indications.—The jugular vein has been ligatured for injuries, on account of involvement in inflammatory and malignant growths, and in cases of thrombosis of the lateral sinus, the object of the operation in the latter case being to prevent septic material from reaching the general circulation by this route.

Position.—The patient is placed in the dorsal position, with the shoulders raised by a pillow, and the head turned towards the opposite side. The operator stands on the affected side of the patient, and the assistant opposite to him.

Operation.—An incision 3 inches in length is made in the line of the vessel, commencing above at the level of the apex of the mastoid process (Fig. 396). The skin, superficial fascia containing the platysma, external jugular vein, and superficial nerves, and the deep fascia are divided, and the sterno-mastoid muscle exposed along its anterior margin. The sterno-mastoid is retracted laterally and the fascia which forms its sheath posteriorly incised, the accessory nerve (spinal accessory) being avoided. The posterior belly of the digastric muscle will now be seen crossing the bottom of the wound obliquely. This structure is pulled upwards with a retractor, and then a sheath of deep cervical fascia, which encloses the jugular vein, will be exposed. This fascial sheath is opened on the lateral side, the vein is separated from the sheath for about one-third of an inch and an aneurysm needle passed unthreaded from the medial side. Care must be taken not to mistake a large tributary—the common facial vein—for the main vessel. The vagus nerve lies behind and medial to the vein, and must be avoided in passing the ligature, and the internal carotid artery immediately medial. The hypoglossal nerve or its descendens cervicis branch may be met with at the lower border of the digastric muscle, in which case the former is drawn upwards and the latter inwards.

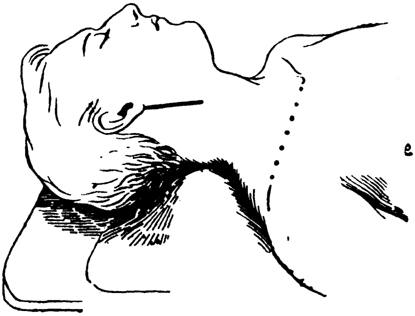

FIG. 396.—Position of patient, and line of incision in exposure of jugular vein.

Exposure or ligature of the transverse (lateral, O.T.) sinus.—The transverse sinus may become the seat of inflammation and thrombosis, owing to the extension of septic affections from the mastoid process, in cases of disease of this portion of the temporal bone. The portion of the sinus which is usually involved is that part which lies in the groove of the mastoid portion of the temporal bone. The course of the sinus is demarcated by drawing a line from the external occipital protuberance to the anterior border of the base of the mastoid, on a level with the external auditory meatus. The sigmoid portion of the sinus lies directly underneath the line of reflection of skin from the mastoid process to the posterior aspect of the pinna. The sinus is usually exposed as it lies in connection with the mastoid process.

Special instruments.—A medium-sized trephine, a periosteal elevator, a chisel and mallet, and gouge.

Position.—The patient is placed in the dorsal position, with the head near the end of the table and toward the sound side. The operator stands on the affected side of the head, and the assistant opposite to him.

Operation.—A curved incision about 2 inches in length is made parallel to the posterior free border of the external auricle. The incision is somewhat semicircular in shape, the convexity looking backwards, and the central point opposite the line of the sinus. The first cut divides everything down to the surface of the bone, including the periosteum, and when this has been done a flap is separated with a periosteal elevator. In the upper part of the incision the lower and posterior fibres of the temporal muscle will be divided, and the insertion of the sterno-mastoid separated from the base of the mastoid process. When this flap has been turned forwards the posterior margin of the wound is retracted backwards, and then a circle of bone is removed with the trephine. The pin of the trephine is placed a little above the central point of the base of the mastoid process. Great care is necessary in this stage of the operation, as the bone is usually of varying thicknesses in different parts of the circle, and the sinus is easily opened with the trephine before the bone has been cut through all round. Many surgeons discard the use of the trephine altogether for this operation, and remove the requisite amount of bone with the mallet and chisel, or gouge. In thrombotic cases, however, injury of the sinus in removal of bone is of no moment, since the lumen of the blood vessel has already been occluded as the result of the pathological process. When the bone has been removed the sinus will be visible in the bottom of the wound, and can then be further dealt with as the circumstances of the case demand.

Varicose veins.—This condition is most frequently met with in the superficial veins of the lower extremity, especially in the large and small saphena veins and their tributaries. The large saphena vein commences on the medial side of the dorsum of the foot, passes proximally in front of the medial malleolus on the medial side of the leg, behind the medial condyle of the femur, and terminates by passing through the saphenous opening in the fascia lata of the thigh and joining the femoral vein. When ligaturing the large saphena vein at the saphenous opening—in Trendelenburg's operation—the vessel will be found lying between the deep membranous layer of the superficial fascia and the fascia lata of the thigh. The small saphena vein commences on the lateral side of the dorsum of the foot, passes upwards behind the lateral malleolus, runs along the middle of the calf, and finally perforates the deep fascia in the lower part of the popliteal space, and joins the popliteal vein.

The operation which appears to be the most efficient is the following:—

Operation.—Short incisions are made with the scalpel, in succession, over the most enlarged parts of the veins. The dilated portion of the vein is separated by careful dissection from the surrounding fascia for about 1 inch or more, if the "knot" is very large, and two fine ligatures of chromicised catgut are applied at the extremities of the exposed part. The portion of vein which lies between these ligatures is excised, and the incisions in the skin closed carefully with fine salmon-gut sutures, and a dressing applied. When the skin over a group or mass of varicose veins is much thinned, discoloured or pigmented, or the seat of a scar, the result of former ulceration, an elliptical incision should be made around the thinned or discoloured area and the part excised.

Trendelenburg's operation for varicose veins.—Trendelenburg's operation consists in exposure of the internal saphenous vein immediately below the saphenous opening, application of two ligatures to the vein—one at a distance of 2 inches below the saphenous opening and the other about 3 inches lower—and excision of the intervening portion.

Operation.—An incision about 2 or 2½ inches in length is made obliquely across the course of the vein and 2 inches below the level of the saphenous opening. The skin and subcutaneous tissues are divided until the vein is exposed. It can be readily recognised by its size and bluish colour. By careful dissection the vein is separated from its fascial connections for a distance of about 3 inches, the lower margin of the wound being strongly retracted for the purpose. Next, each extremity of the exposed portion of vein is surrounded and tied with a catgut ligature and the part between the two ligatures excised. Afterwards the external wound is closed by sutures and dressings applied. No drainage is necessary.

Venesection.—The operation of venesection or " bleeding " is only occasionally performed at the present day.

The operation is indicated in the following clinical conditions namely :—

(*a*) In some cases of pneumonia of traumatic origin, when the patient is a " full-blooded " person and the affection extends rapidly.

(*b*) In some cases of chronic bronchitis, when the the heart is much impeded owing to the right side of the organ being much distended and engorged with blood.

(*c*) In certain cases of impending apoplectic seizures, where a tendency to the occurrence of this condition exists.

(*d*) In the treatment of some forms of aneurysm, especially when they are intrathoracic.

When the operation of venesection is considered necessary, from 8 to 10 oz. of blood are removed in the following manner, and in many cases it will be found necessary to repeat the procedure. In the treatment of aneurysms only small quantities are removed, just sufficient to reduce excessive action of the heart.

Special instruments.—A small scalpel or a bleeding-lancet, a bandage, a bleeding-bowl, an aseptic pad, and a small narrow bandage.

Position.—The patient is placed in the sitting position, the arm hanging over the side of the chair. The surgeon stands on the outer side of the limb upon which he proposes to operate.

Operation. A superficial vein is chosen, which is of moderate size and can be easily dealt with. In most cases the median basilic or the median cephalic vein of the arm is selected. The vein in this situation is quite superficial, and in addition to receiving the blood from the anterior aspect of the forearm it has a wide communication with the deep veins in the cubital fossa, by means of the deep median vein.

A bandage is applied to the middle of the upper arm, and tied sufficiently tightly to stop the circulation in the veins, but to still allow the flow of blood along the arteries. A roll of paper, a bandage, or a piece of wood is placed in the hand of the patient, and he is told to grasp it during the operation. This serves to divert the attention of the patient, as well as to force the blood of the limb into the superficial veins. The median basilic or the median cephalic vein is then chosen, whichever is the more prominent, care being taken to avoid any abnormal artery which may be given off from the brachial and lie in the fascia at the bend of the elbow.

The thumb of the surgeon's left hand is placed on the selected vein a short distance beyond the point which is to be punctured, so as to control the flow of blood. A bleeding-lancet or a sharp scalpel is then taken in the right hand, and grasped between the finger and thumb in such a manner that only about ½ inch of the blade projects. A small cut, about ½ inch in length, is then made with one sweep of the blade, dividing the skin, fascia, and anterior wall of the vein. Care must be taken not to penetrate the posterior wall of the vein, in which case it would be possible to damage one of the adjacent arteries. If the first cut does not extend into the lumen of the vein, a second one is made in a similar manner, but the opening in the skin and in the fascia must be larger than that in the vein.

When the vein has been opened a bleeding-bowl is placed beneath the elbow, the left thumb is removed from the surface of the vein below, and the stream of blood allowed to flow until the requisite amount has been removed. During the evacuation of the blood the affected limb should not be moved, so as to avoid entrance of the blood into the surrounding subcutaneous tissue.

The necessary amount of blood having been removed, the left thumb is placed upon the opening in the vein and the bandage from the upper arm taken off. A small pad of lint or gauze is next placed upon the wound, and fixed in position by the narrow bandage, which is applied in the figure-of-eight fashion.

This dressing is kept on for two or three days, and then discontinued. The limb ought to be kept in a sling for a few days longer.

If the artery is injured at the time of the operation, it may be followed by the formation of an arterio-venous aneurysm, owing to the establishment of a communication between the lumen of the vein and that of the artery.

Intravenous injection of saline fluids.—The intravenous injection of saline fluids, especially sodium chloride 0·75 per cent. in sterilised water, has been practised with success in a number of cases. The indications for this proceeding appear to be the following, namely :—

1. Acute anæmia, dependent upon the following causes :—

(*a*) Severe hæmorrhage after an accident, such as the cutting off of a limb in a railway smash, or after attempted suicide or homicide, when a large vessel has been severed, in cases of "cut throat," etc.

(*b*) Severe loss of blood during a surgical operation.

(*c*) Severe loss of blood in connection with parturition, as in placenta prævia, morbidly adherent placenta, accidental hæmorrhage, and post-partum hæmorrhage.

It ought to be borne in mind that, unless the bleeding points have been securely ligatured, injection will only tend to restart the hæmorrhage.

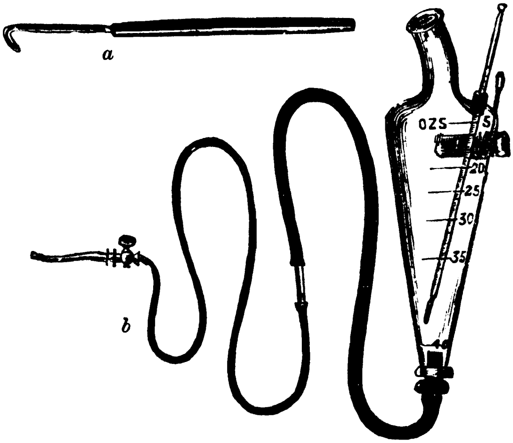

FIG. 397.—Apparatus for the intravenous injection of fluids.

a. Cannula introducer. *b*. Injection apparatus. The cannula is inserted into a vein of the recipient, and the reservoir is filled with the fluid which it is wished to inject. Pressure is obtained by raising the reservoir to a suitable height above the patient. The thermometer is to indicate the temperature of the fluid which is being injected.

2. In some cases of shock and collapse, when the action of the heart is very weak, and there is impending dissolution.

It is only in occasional cases of this kind that the injection of a saline fluid can be expected to be of much benefit.

3. In cases of toxæmia, such as uræmia and diabetic coma.

4. In cases of severe loss of fluid from the intestine, *e.g.* cholera, infantile diarrhœa.

Special instruments.—Elastic rubber tube, fine scalpel, fine-pointed dissecting forceps, aneurysm needle, cannula introducer (Fig. 397, *a*), injection apparatus with cannula (Fig. 397, *b*), needle, needle-holder, and ligature material.

Preliminary preparations.—Three to six pints of water are boiled in order to render it sterile. Then a sufficient quantity of sodium chloride is added to make the solution of a strength of 0·75 per cent. (a drachm to a pint is sufficiently approximate for practical purposes).

Glass tubes containing sterile salt for making physiological and normal saline solution can be readily obtained from commercial sources. Each tube contains—

Calcium chloride . . .	0·25 grms.
Potassium ,, . . .	0·1 ,,
Sodium ,, . . .	9·0 ,,

and is sufficient for one litre of solution.

The solution thus prepared is kept at a temperature of 100° to 105° F.

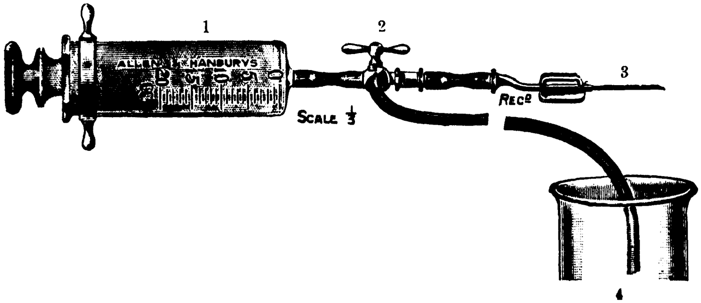

FIG. 398.—Injection syringe for intravenous administration of Salvarsan.
1. Syringe. 2. Three-way valve. 3. Needle. 4. Receptacle for solution.

Immediately before the apparatus is used it is washed out with hot sterilised water, and then filled with the saline fluid.

Operation.—The vein to be opened having been decided upon (the median basilic or the median cephalic, just above the bend of the elbow, is most convenient, though in very anæmic persons it may be necessary to expose one of the deep veins of the arm), the elastic rubber tube is wound round the limb on the proximal side of the vein. An incision is made through the skin along the course of the vein, and this structure is dissected free from the surrounding fascia for a distance of an inch. The vein lies in the superficial fascia, and embedded in fatty tissue. A silk ligature is passed with the aneurysm needle underneath the vein at each extremity and in the middle of the incision. The distal ligature is then tied.

The anterior wall of the exposed vein is picked up with the fine forceps, and a small transverse incision made into it. The cannula introducer (Fig. 397, *a*) is now taken and passed into the interior of the proximal end of the vein. The cannula of the injection apparatus (which has already been filled with fluid) is passed into the vein on the grooved under aspect of the introducer. The cannula introducer is withdrawn, and the middle silk ligature tied around the neck of the cannula. The elastic rubber tube is now removed. The stopcock of the injection apparatus is turned on, the reservoir gradually raised by an assistant, and a sufficient amount of fluid allowed to flow into the vein. Usually two to four pints will be found to be sufficient.

The upper ligature is now tied above the point of the cannula, and the instrument withdrawn. The incision is sponged dry and closed by the insertion of one or two points of interrupted silk sutures.

Intravenous injection of Salvarsan and other Drugs in Solution.—Salvarsan and other similar remedial agents in solution may be injected in a manner similar to that made use of in the intravenous injection of saline solution. Sometimes a special syringe and needle, such as depicted in Fig. 398, are used in the administration of salvarsan and other arsenical preparations. The needle is a sharp one, and may be pushed directly into the vein through the skin.

Blood Transfusion.—*Indications.*—

1. Acute anæmia from whatever cause.
2. Traumatic shock.
3. In hæmophilia and other hæmorrhagic diseases.

Transfusion of blood may also be used to counteract loss of blood and shock as a measure giving additional safety during the performance of any severe operation.

Precautions.—Blood transfusion must not be undertaken, except in cases of extreme urgency, without a preliminary test to eliminate the danger of incompatibility between the blood of the recipient and that of the donor. This can be done by "grouping" with stock sera collected from individuals of groups ii. and iii. If the donor belongs to group iv. (Moss), the recipient need not be grouped; otherwise the donor and recipient must belong to the same group. If no stock sera are available, some blood must be taken from the recipient and the serum tested against the corpuscles of the donor, who can only be used if no agglutination takes place. Syphilis in the donor should be guarded against wherever possible by ascertaining that his blood shows a negative Wasserman reaction.

Operation.—The operation is divided into two stages: (1st stage)—*Drawing of blood from the donor.* (1) The donor's right or left arm is chosen, according to which shows the more prominent veins in the antecubital fossa. He is put in the recumbent position, and a tourniquet is applied to his upper arm so as to produce venous congestion. The skin over a suitable vein is cleansed with ether and a small cutaneous weal is made over the vein with a hypodermic syringe containing 1 or 2 per cent. novocaine. With the point of a scalpel a superficial incision 5 cm. in length is made through the weal in the line of the vein. Through the upper end of the incision the anterior wall of the vein is transfixed with a fine round-bodied needle. A large "transfusion needle" of not less than 2 mm. bore is then plunged into the vein underneath the transfixing needle, and the blood is allowed to flow through a short rubber tube into a flask containing the requisite amount of sodium citrate in solution. One gramme of sodium citrate in 50 c.cms. of water is required as an anticoagulant for each 450 c.cms. of blood. The blood

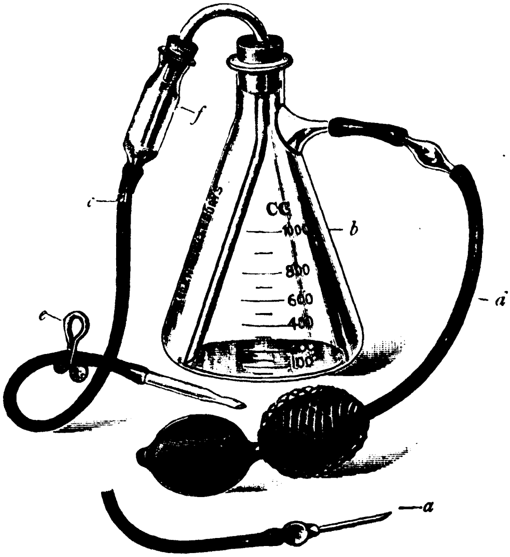

FIG. 399.—Blood transfusion apparatus.—GEOFFREY KEYNES.

a. Transfusion needle. *b.* Flask. *c.* Delivery tube and cannula. *d.* Rubber bellows and connecting tube. *e.* Clip. *f.* Glass air-lock on delivery tube.

and sodium citrate solution must be very thoroughly mixed by shaking the receiver while the blood is flowing, if the formation of any clot is to be prevented. When enough blood has been collected, usually the tourniquet is removed from the donor's arm and both needles from his vein, and a small dressing is applied. Some pressure may be needed for a short time to prevent further bleeding. No suture is required.

(2nd stage)—*Injection of the blood into the patient.* If no special apparatus is available the citrated blood may be introduced into the patient's circulation by means of a funnel and cannula exactly as for intravenous infusion of saline solution (see p. 583). For surgical cases, however, it is better to be able to control accurately the injection of the blood. It is, therefore, usually received from the donor into a flask provided with a delivery tube and a second tube for the attachment of a rubber bellows (Fig. 399). From the delivery tube a rubber tube leads to a cannula which is tied into a vein in the patient's arm. Before the cannula is introduced the system is filled with fluid and the rubber tube is clipped. The pressure in the flask is raised by means of the bellows as the clip is released, and the blood then flows into the patient's veins. Great care must be used to reapply the clip to the tube before the flask is completely emptied in order to avoid introducing air into the patient's circulation. The cannula is then removed from the vein, which is tied, and the wound is sutured in the usual way. Except in a very much exsanguinated patient, the blood should be injected slowly ; more precise control of the speed of injection and greater safety against air embolus is obtained by the addition of a glass air-lock to the delivery tube.

CHAPTER XXV

OPERATIONS UPON NERVES

THE surgical operations which are performed upon the nerve trunks or branches in their continuity may be divided into eight groups :—

(*a*) Suture of divided nerves, or neurorrhaphy.
(*b*) Nerve stretching.
(*c*) Division of a nerve, or neurotomy.
(*d*) Excision of a portion of a nerve, or neurectomy.
(*e*) Nerve transplantation.
(*f*) Nerve anastomosis.
(*g*) Nerve crossing.
(*h*) Excision of ganglia.
(*i*) Injection of alcohol or other substance into nerves and ganglia.

In order to perform these different operations, it is necessary, in the first place, to expose fully that portion of the nerve trunk or trunks upon which it is proposed to operate. In this chapter the general principles to be observed in performing these operations will be first described, and afterwards the methods of exposing the individual nerve trunks.

General considerations.—Operations upon nerve trunks are generally necessary either on account of an injury to a nerve or to the adjacent tissues, or owing to the formation of a tumour in connection with a nerve, or the involvement of a nerve by the extension of a malignant growth from the neighbourhood. Occasionally it is necessary to divide the sensory nerve supplying an organ which has become the seat of a malignant growth, as in squamous-celled carcinoma of the tongue, in order to relieve the excessive pain from which the patient is suffering. Division or even excision of a portion of a sensory nerve may be required in some cases of intractable neuralgia. Motor nerves may require division in some cases of severe muscular contraction, depending upon an affection of the nerve or of the corresponding nervous centre, as in some forms of wryneck, when it may be necessary to divide the accessory nerve.

Whenever a nerve trunk has been divided by an injury, it is advisable to expose the severed ends and make an attempt to unite them, or, if this is impossible, to transplant a portion of nerve into the gap, or to perform nerve anastomosis with an adjacent nerve. Indirect union of the divided extremities of a nerve has been attempted by passing strands of catgut from one end to the other, and by the interposition of a tube of decalcified bone, celloidin, prepared animal's arteries, or a segment of one of the superficial veins of the patient in the region of the injury. This procedure, however, has not been very successful; better results are obtained in cases of this kind by transplantation of nerve or by nerve anastomosis.

Nerve ganglia, such as the semilunar (O.T., Gasserian) ganglion, have been excised with the view of curing intractable neuralgias which have not proved amenable to less severe forms of treatment.

Primary tumours of nerves are not common, but neuromata, either true or of the nature of fibrous tumours, myxomata, and sarcomata occur and require treatment.

It occasionally happens that a nerve trunk becomes involved in the callus formed in the repair of a fractured bone, in which case it may be necessary to expose the nerve, in order to free it from the new-formed tissue in which it has become embedded, or by which it has been pressed upon.

Suture of a divided nerve, or neurorrhaphy.—This procedure is rendered necessary when a nerve trunk has been divided by accident or otherwise. If the divided ends of the nerve are united by an operation, performed immediately after the division has occurred, it is called "immediate suture," while if this is not done until some time afterwards, the term "secondary suture" is applied.

Immediate suture.—In union of a nerve by immediate suture the nerve is sought for in the wound, and the two ends freely exposed; and if there has been any laceration or bruising of the divided nerve the irregular tags are cut away with a sharp scalpel, so as to leave two clean ends which can be easily brought into exact apposition. When there has been much laceration and it is found requisite to remove a portion of the nerve trunk, it may also be necessary to free each of the divided ends for a short distance so as to facilitate their approximation. Great care must be taken to avoid any axial rotation of the nerve trunks, so that, when approximated, as far as possible the cut ends of individual nerve fibrils shall be in contact. The two ends are next fixed in apposition by the introduction of several sutures of fine chromicised catgut, the number of sutures varying according to the size of the nerve (Fig. 400). A small rounded needle or a small Hagedorn's needle is used for the introduction of the sutures. Each suture is passed through the entire nerve substance, about a quarter of an inch from the cut surface of each extremity, all the sutures being introduced before any are tied. When sufficient sutures have been put in they are carefully tied and the ends cut short. The sutures must not be tied too tightly, or they will cut out; it is sufficient to tie them in such a manner that the cut surfaces are fixed in approximation. When this has been done, it is advisable, if possible, to put in several fine sutures through the fibrous tissue forming the sheath of the nerve. When the two ends of the nerve have been united in this way, the entire wound is thoroughly cleansed, and closed with sutures in the usual manner. Care should be taken to approximate the tissues in the deep part of the wound, especially in the neighbourhood of the injured nerve, so as to avoid any undue tension which might tend to separate the sutured nerve ends. In order to effect this it will be found advisable in some cases to unite the deep part of the wound with several deep sutures.

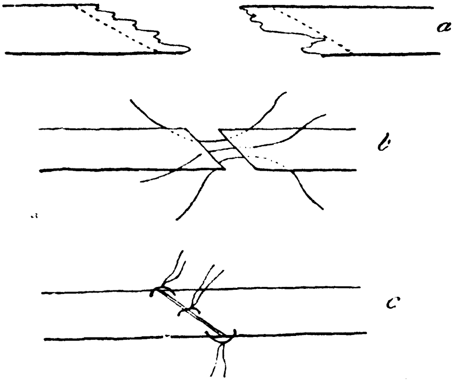

FIG. 400.—Primary suture of a divided nerve.

a. Divided nerve with lacerated extremities.
b. Extremities pared and sutures inserted ready for tying.
c. Ends approximated and sutures tied.

Secondary suture.—In the union of a nerve by secondary suture the divided ends are first exposed by an incision made through the overlying tissues in the long axis of the injured nerve. It is necessary in many cases to make a long incision, owing to the ends of the divided nerve having become separated or extensively involved in scar tissue.

The proximal end of the nerve is usually found to have become enlarged and bulbous, while the distal end is atrophied and embedded in the scar tissue. In some cases the distal end is very much shrunken, and appears as a fine thread (Fig. 401). When considerable difficulty is experienced in locating the position of the distal end, it is advisable to expose the nerve a

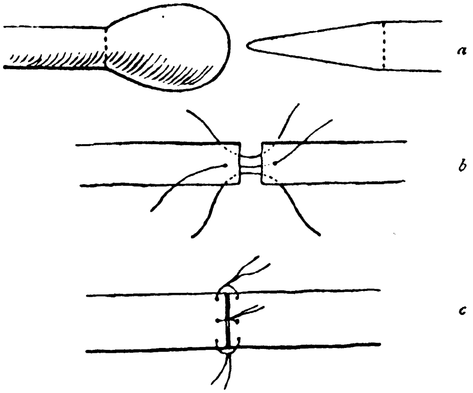

FIG. 401.—Secondary suture of a divided nerve.

a. Divided nerve with proximal end enlarged and bulbous, and distal end attenuated.
b. Nerve pared and sutures inserted ready for tying.
c. Suture completed.

short distance beyond the point of division, and then to trace the trunk upwards. When the two ends of the nerve have been fully exposed they are dissected free from the surrounding scar tissue, and cut across with a sharp scalpel so as to lay bare areas of freshly cut nerve for approximation. The proximal end should be cut across just before the enlarged portion joins the healthy nerve trunk, care being taken that the section exposes healthy nerve bundles. A small portion only of the distal end is excised, generally about one-fourth or one-third of an inch, as in most cases the nerve fibres in this portion have undergone considerable degeneration. The two ends having been prepared in this manner, they are united according to the method described in connection with "immediate suture." In cases of secondary suture there is more scar and fibrous tissue in the sheath of the nerve, and on this account it is not always easy to fix the two ends in apposition. When the ends have retracted, and are separated from one another by a short interval, it is necessary to free the nerve both proximally and distally for a short distance, and, if in the immediate region of a joint, to flex or extend the joint as much as possible, according to the position of the divided nerve on the flexor or extensor aspect of the limb, before the two ends can be approximated without exerting undue tension. In case of injury to the ulnar nerve in the region of the elbow, the divided ends may be transplanted in front of the elbow-joint, and then, when the forearm is flexed, suture may be possible.

A preliminary operation for stretching the extremities of the cut nerve may be necessary. The ends of the nerve are exposed through a suitable incision and freed for several inches. A couple of strong catgut sutures are now passed through the divided ends of the nerve, and tied as tightly as possible, with the limb held in a position to slacken the nerve to its maximum extent. The wound is closed, and after two or three days the nerve is stretched daily by gentle manipulation of the limb. At the end of ten days the wound is reopened and the nerve exposed, and if possible the ends pared and sutured.

If the ends of a divided nerve are embedded in much scar tissue, or the nerve has been extensively lacerated at the time of the injury, it may be impossible to bring the prepared extremities into apposition by the above procedure.

When this condition is met with, an attempt should be made to fill the space between the divided extremities by transplantation of a portion of a nerve in the immediate neighbourhood (*auto*-transplantation), or by transplantation of a portion of a nerve from the limb of another patient which has just been amputated (*homo*-transplantation). If neither of these methods are feasible, anastomosis of the peripheral portion of a divided motor nerve with an adjacent motor nerve should be attempted, since transplantation of a portion of nerve of an animal into the space, bridging over the gap with strands of catgut, tubes of decalcified bone or celloidin, prepared animal's arteries, or a segment of one of the superficial veins of the patients, have not been followed by such good results as nerve-transplantation ("*auto*" or "*homo*") or nerve anastomosis.

Turning down a segment of the nerve to close the gap between the divided extremities has also given bad results, probably on account of the larger amount of fibrous tissue which results from this procedure.

Occasionally, as in the case of the radial (O.T., musculo-spiral), the two divided nerve ends may be approximated after removing a segment of the bone of the limb—humerus. This should only be done when a fracture already exists.

Nerve stretching. — The nerve trunk which it is desired to stretch having been fully exposed, according to the methods described in connection with individual nerves, it is carefully separated from the surrounding tissue and lifted up in the wound. In the case of the large nerves, such as the great sciatic, the finger and thumb are used for stretching, whilst in the case of small nerves a blunt hook of suitable size will be found most convenient (Fig. 402). When the nerve has been seized with the finger and thumb, or a hook has been placed underneath it, steady tension, gradually applied, is exerted, the amount of tension varying with the size of the nerve. Thus, when the sciatic is being stretched, a force of 30 lb. may be exerted, while for a small nerve, such as the supra-trochlear, not more than half a pound should be employed.

The tension is exerted first on the proximal portion for about two to five minutes, and then for a similar period on the distal section. When the nerve has been stretched in this manner it is replaced in its former position, and the external wound closed.

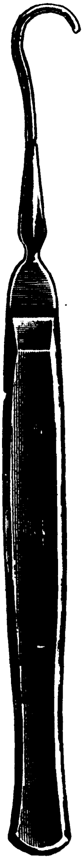

FIG. 402. — Blunt hook, suitable for stretching a small nerve.

Division of a nerve, or neurotomy.—This operation may be performed either through an open incision or subcutaneously. In the great majority of cases it is preferable to adopt the former method. The nerve trunk is exposed in the usual manner, and then cut across either with the scalpel or scissors.

Excision of a portion of a nerve, or neurectomy.—This operation is similar to the preceding, with the exception that a larger portion of the nerve is exposed, and a small piece removed by cutting through the nerve in two places, and taking away the intervening part.

Neurectomy and neurotomy are operations which are performed only on small sensory nerves, such as the supra-orbital; but large branches are divided in exceptional cases, such as the lingual in cancer of the tongue and divisions of the trigeminal nerve in severe intractable neuralgia of that nerve.

In all cases of operations upon nerves, care must be taken not to seize the nerve trunk with forceps or similar instruments, as this always leads to bruising of the nerve fibres.

Nerve transplantation.—By *nerve transplantation* is understood removal of a portion of a nerve from another place to fill in a gap or space between the separated extremities of a divided nerve. This portion of a nerve may be removed from another nerve of the patient, when the operation is distinguished as *auto*-nerve transplantation; from the amputated limb of another patient, when it is called *homo*-nerve transplantation; and from the nerve of an animal, in which case it is known as *hetero*-nerve transplantation. *Auto*- and *homo*-nerve transplantation have given good results, but *hetero*-nerve transplantation ought to be discarded, on account of the bad results which have followed its practice.

In the operation of *auto*-nerve transplantation the incision which has been made in order to expose the injured nerve is prolonged so as to lay bare an adjacent nerve which is suitable. This having been done, a segment is cut out of it with a sharp scalpel, transferred to the gap between the divided ends, and fixed by the insertion of a few interrupted sutures of fine chromicised catgut.

This form of operation is applicable in cases where a nerve like the radial (O.T., musculo-spiral) is the seat of injury, and a segment of the superior branch of the radial can be transplanted so as to fill the gap. Of course, a large nerve must not be sacrificed for the purpose.

Nerve anastomosis.—By nerve anastomosis we mean the establishment of a direct connection by approximation of the cut surface of an injured or divided nerve with the cut surface of a portion of an uninjured nerve in the immediate neighbourhood. When the operation of nerve anastomosis is being performed the injured nerve is exposed through a free incision, freed from its fascial connections or scar tissue, if any be present, and a clean transverse or oblique section made through it with a sharp fine scalpel, great care being taken to avoid bruising or laceration of the nerve by severe handling. Next, the adjacent nerve, with which it is proposed to establish the anastomosis, is similarly separated from its surroundings by careful dissection, and any tissues lying between the two nerves pulled aside or cut away.

The method of making the anastomosis varies according to the size of the injured nerve and the ease with which it can be brought into apposition with the sound nerve without undue tension.

If the nerve to be anastomosed is small, a vertical incision is made in the sound nerve, and the prepared end of the injured nerve implanted in it and fixed there by the insertion of two or more sutures of very fine chromicised catgut. When the injured nerve is fairly large, and can easily be brought into apposition with the sound nerve, a somewhat oblique incision is made through about one-fourth or one-third of the sound nerve, and the prepared end of the injured nerve also is cut slightly obliquely.

The two surfaces are placed in apposition, and fixed by the insertion of two sutures of fine chromicised catgut, each passing through the nerves immediately above the cut ends.

In those cases where the injured nerve and the sound nerve cannot easily be brought together without tension, the injured nerve is prepared by making the section transverse, and next the sound nerve is divided transversely for one-fourth or one-third of its thickness, and the segment so cut through separated for some distance from the nerve trunk by splitting. The two prepared surfaces are then placed together and fixed by the insertion of fine catgut sutures, as in the previous case.

Nerve crossing.—The term nerve crossing is restricted to the operation in which an adjacent sound nerve is completely cut across and its central end anastomosed with the prepared peripheral end of an injured nerve (Sherren). The operation has most frequently been performed between the facial nerve and the hypoglossal (see p. 605).

Excision of nerve ganglia.—Removal of a nerve ganglion, together with the adjacent portions of the nerve trunk with which it is connected, has been practised for the relief of some forms of severe neuralgia which are not amenable to milder forms of treatment. The semilunar (O.T., Gasserian) ganglion and the spheno-palatine ganglion have been removed for intractable neuralgia of the second or third divisions of the trigeminal nerve. In some cases very good results have followed the performance of the operation, but the comparative value of these procedures has not yet been decided.

Exposure of or Operations upon Individual Nerves and Ganglia

The trigeminal nerve—The supra-orbital nerve.—The nerve is one of the cutaneous branches of the first division of the fifth. It passes out from the orbit through the supra-orbital foramen or notch, which can be felt at the junction of the medial with the intermediate third of the superior margin of the orbit.

Position.—The patient lies in the dorsal position, with his head supported by a pillow ; the surgeon stands at the head of the patient, and his assistant opposite to him.

Operation. — The eyebrow having been shaved, an incision not quite an inch in length is made along the supra-orbital margin, the centre being opposite to the point of exit of the nerve (Fig. 403, *a*). The skin, fascia, and fibres of the orbicularis oculi muscle are divided in the line of the incision, and then the nerve will become visible, lying upon the bone just beyond the notch or foramen, in company with the supra-orbital artery. The nerve may be found to have already divided into two branches at the point where it emerges from the notch or foramen. The nerve is next separated from the vessel, and can then be stretched. Care must be taken in this operation for nerve stretching not to divide the nerve as it lies upon the bone.

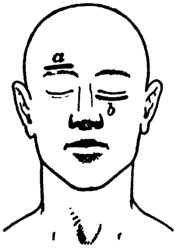

FIG. 403. — Exposure of supra-orbital and infra-orbital nerves.

a. Incision for supra-orbital nerve.
b. Incision for infra-orbital nerve.

The infra-orbital nerve.—The infra-orbital nerve emerges through the infra-orbital foramen, which is situated directly below the middle of the lower margin of the orbit. It passes from the pterygo-palatine fossa along the floor of the orbit to reach the infra-orbital foramen.

Operation.—1. *Exposure of nerve on face by incision through cheek.*—The patient is placed in the same position as for exposure of the supra-orbital nerve ; the surgeon stands on the affected side of the head and the assistant opposite to him.

An incision about 1 inch in length is made along the lower margin of the orbit, the centre of the incision being opposite to the foramen (Fig. 403, *b*). The skin, fascia, lower fibres of the orbicularis palpebrarum, and the attachment of the levator labii superioris are divided, and the nerve sought for where it emerges as several branches from the foramen.

2. *Exposure of nerve in infra-orbital canal.*—In order to expose that portion of the nerve which lies in the canal, the periosteum of the floor of the orbit is detached, and the contents of the orbital cavity with the periosteum lifted up and held away from the field of operation with a retractor. The thin bony plate which forms the roof of the canal in which the nerve lies is carefully removed with a fine grooved chisel, and the nerve lifted up from its bed.

3. *Exposure of nerve from the mouth.*—The nerve may also be exposed by dividing the mucous membrane of the mouth, where it is reflected from the alveolar process on to the inner surface of the upper lip of the affected side. When this has been done, the structures which lie superficially are separated from the bone with a periosteal elevator, until the foramen is reached and the nerve exposed. The advantage of this method of operating is the absence of a visible scar.

Removal of the spheno-palatine (O.T., Meckel's) ganglion, and division of the maxillary division of the trigeminal nerve in the pterygo-palatine fossa.—This operation has been carried out—

(*a*) Through an incision below the margin of the orbit, and then chiselling a hole through the maxilla, opening the antrum and extending the wound into the pterygo-palatine fossa by removing a portion of the posterior wall of the antrum ; and also

(*b*) By a deep dissection of the pterygoid region, after the zygoma has been exposed, divided, and turned downwards.

Removal of the semilunar (O.T., Gasserian) ganglion.—The semilunar ganglion is situated within the skull between two layers of dura mater, in a depression of the middle cerebral fossa immediately behind the foramen ovale at the apex of the petrous portion of the temporal bone.

Indications.—Removal of the semilunar ganglion is necessary and advisable only in those severe cases of trigeminal neuralgia which will not respond to palliative treatment, and in which the patient's life is made unbearable by the severity of the pains along the course of the branches of the fifth cranial nerve.

Removal of the semilunar ganglion (O.T., Gasserian) through the temporal region.—*Special instruments.*—As for craniotomy, with the addition of a suitable retractor.

Position.—The patient is placed in the dorsal posture, with the head turned over towards the unaffected side, and supported by a firm pillow. The surgeon stands on the same side as the lesion, and his assistant directly in front of him.

Operation.—(*a*) *External incision and resection of skull wall.*—A ∩-shaped incision is made in the temporal region of the affected side, which commences above the zygoma and behind the lateral angular process of the frontal bone, extends upwards to the temporal crest, and downwards to a point ½ inch in front and the same distance above the external auditory meatus (Fig. 404). This incision divides all the tissues down to the bone. With a surgical motor saw, or a chisel and mallet, preferably the former, the skull wall is divided along the line of the skin incision, whilst at the base of the flap the soft tissues are lifted up and the underlying bridge of bone cut through. When this has been done a ∩-shaped flap can be turned downwards, which consists of all the soft structures of the scalp and a segment of the cranial wall. If more room should be required in the later stages of the operation, the zygoma may be divided as described on page 600 (Fig. 406).

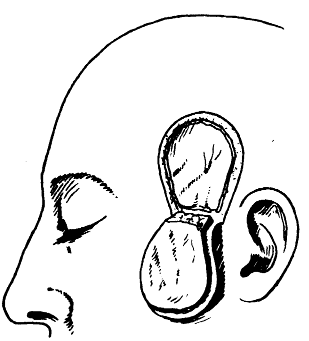

FIG. 404.—Removal of semilunar (O.T., Gasserian) ganglion. Position of skin incision and shape of flap which is turned down.

(*b*) *Lifting up of dura mater and superjacent brain, and ligature of middle meningeal artery.*—With a rectangular periosteal elevator the dura mater is separated from its attachment to the skull wall in the direction of the base of the skull and towards the middle line. The middle meningeal artery will be seen lying upon the dura mater, and between it and the bone. The main trunk of this is followed towards the foramen spinosum by lifting the dura mater and the brain upwards and inwards. At or near the foramen spinosum the trunk of the vessel is surrounded by two ligatures and divided between.

(*c*) *Exposure and removal of the semilunar ganglion.*—The separation and lifting up the dura mater is continued towards the median line and towards the base of the middle cerebral fossa, until the depression in which the ganglion lies at the apex of the petrous portion of the temporal bone is laid bare. By careful dissection the ganglion is separated from its attachments to the dura mater and the periosteum of the base of the skull, and the maxillary and mandibular branches of the trigeminal nerve are exposed as far as the foramen rotundum and the foramen ovale. These branches are cut through close to the foramina, and the two portions of nerve and ganglion pulled in an outward direction so as to render tense the portion of nerve on the proximal side of the ganglion. When this has been done the nerve is cut through as close to the dura mater as possible, and the ganglion with the attached portion of nerves removed.

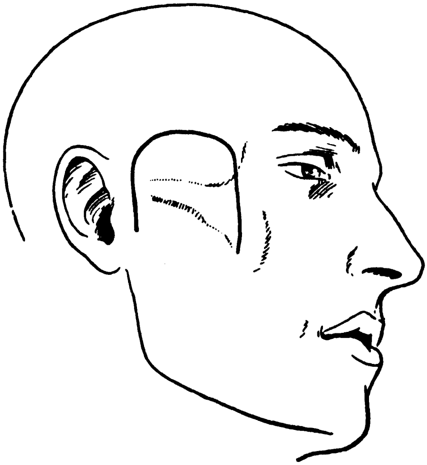

FIG. 405.—External incision for exposure and removal of semilunar ganglion (O.T., Gasserian) through the pterygoid region.

(*d*) *Closure of the external wound.*—The space in the base of the skull from which the ganglion has been removed is sponged dry, and the dura mater and brain allowed to fall back into their normal position. The flap of scalp and skull wall is then replaced, and the margins of the external incision united by sutures of salmon-gut. When the zygoma has been divided it is fixed with wire sutures.

Removal of the semilunar (O.T., Gasserian) ganglion through pterygoid region.—*Position.*—The position of patient and operator and the instruments required are the same as in the previous operation.

Operation.—For convenience of description this operation may be divided into the following stages :—

(*a*) *Skin incision.*—A ∩-shaped incision is made which commences a little below the anterior extremity of the zygomatic arch or malar prominence, extends upwards to the level of the lateral angular prominence of the frontal bone, backwards to a line prolonged upwards from a point ½ inch in front of the external auditory meatus, and then downwards so as to terminate about ½ inch below the posterior part of the zygoma (Fig. 405). The flap thus marked out is turned downwards, and is made to consist of the skin and fascial layers.

(*b*) *Resection of the zygomatic arch.*—With a small saw the bone forming the zygomatic arch is sawn through along the lines shown in Fig. 406. Next, the temporal fascia which is attached by two laminæ to the upper part of the zygomatic arch is cut through, and the zygoma with its attached masseter muscle turned downwards. Care should be taken to make the section of the anterior part of the zygomatic arch well forwards, in order to provide sufficient room for the ready performance of the subsequent parts of the operation.

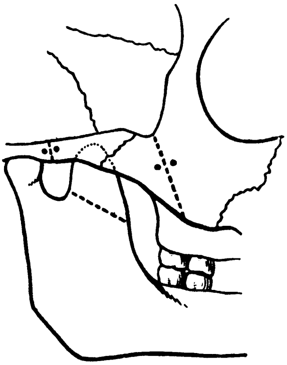

FIG. 406.—Removal of semilunar ganglion (O.T., Gasserian). The dotted lines show where the saw cuts ought to be made in the zygomatic arch and coronoid process. —ROSE.

(*c*) *Detachment of the temporal muscle and exposure of the temporal fossa.*—The coronoid process of the lower jaw, which has been laid bare by throwing down the masseter, is sawn through along the line shown in Fig. 406. During this part of the operation, it must be remembered that the attachment of the temporal muscle extends much lower on the internal and anterior aspects of the process than on the external surface. The bone having been sawn through, the temporal muscle is turned upwards and separated from its connection with the temporal fossa by a periosteal elevator. The deep temporal arteries, branches of the internal maxillary, are met with at this stage, and, when seen, they should be ligatured and turned downwards. The sphenoidal attachments of the external and internal pterygoid muscles are now exposed and detached with the periosteal elevator, and the muscles turned backwards.

The foramen ovale and the mandibular division of the trigeminal nerve and its branches can be readily located now by following upwards one of the exposed nerve branches.

(*d*) *Removal of a portion of cranial wall.*—When the exact position of the foramen has been made out, a trephine, or chisel and mallet, is taken, and a segment of the cranial wall removed from immediately lateral and above this foramen, and in the position shown in Fig. 407, T. Previous to removal of the bone it is usually convenient to expose the trunk of the middle meningeal artery immediately before it passes through the foramen spinosum, and to ligature it. When a trephine is used for removal of the bone, the aperture thus made should be enlarged in a medial and forward direction until it is made to communicate with the foramen ovale. The dura mater of the middle cerebral fossa is next separated from its connection with the bone by a periosteal elevator or a probe-pointed director, especial care being taken not to perforate this membrane and so open the subdural space.

(*e*) *Location and removal of the semilunar ganglion.*—The mandibular division of the fifth nerve is traced medially from the foramen ovale until the semilunar ganglion is reached. This is much facilitated by pressing upwards and backwards the dura mater and superjacent brain with a small spatula. When the position of the ganglion has been thus located it is separated by careful dissection from the dura mater, and then its connections with the sensory part of the fifth nerve cut through with a fine pair of scissors. In some cases it will be found more convenient to take away the ganglion piecemeal, using a small sharp Volkmann's spoon for the purpose.

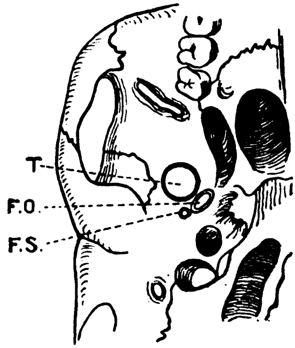

FIG. 407.—Removal of semilunar ganglion. Position of trephine hole in removal of a portion of cranial wall.—ROSE.

F.S. Foramen spinosum.
T. Trephine hole.
F.O. Foramen ovale.

(*f*) *Closure of the external wound.*—All hæmorrhage is arrested by pressure, or ligature where possible, and the segment of bone removed with the trephine is replaced. Next, the coronoid process is sutured with silver wire, the zygomatic arch replaced and fixed with wire sutures, and finally the margins of the skin incision are united with salmon-gut.

Of these two operations, the first presents the most advantages, and in my opinion is the more preferable. The ganglion is effectually removed, the attachments of the muscles of mastication on the affected side are not seriously interfered with, and there is less possibility of septic complications.

The inferior alveolar (inferior dental) nerve.—The inferior alveolar nerve enters the inferior alveolar foramen opposite the centre of the vertical ramus of the lower jaw ; it then runs downwards and forwards in the dental canal.

Position.—The patient is placed in the dorsal position, with the head turned to the opposite side. The surgeon stands on the affected side, and his assistant opposite to him.

Special instruments.—Three-quarter-inch trephine, or small gouge and mallet.

Operation.—A horizontal incision 2 inches in length is made opposite the middle of the vertical ramus of the lower jaw, not higher than the superior border of the lower alveolus. This incision divides the skin and fascia, and contained superficial vessels and nerves.

The margins of the incision are retracted, and the masseter divided in the direction of its fibres, and the outer surface of the vertical ramus exposed. The margins of the whole incision are then well retracted, the trephine applied to the bone, and the outer plate of bone removed.

The trephine is then removed, and, if necessary, the inferior dental canal located with the gouge. In this manner the canal can be opened and the nerve exposed either just before it enters or in the canal. The nerve is then dealt with, the bone may be replaced, and the wound closed.

This nerve may also be reached through the mouth, before it enters the inferior alveolar (inferior dental) foramen, by incising the mucous membrane immediately behind this aperture, or nearer its termination, by chiselling away the outer wall of the inferior alveolar canal in the horizontal ramus.

The results which have followed these operations do not appear to have been very favourable, and on this account it is doubtful if they can be said to be justifiable.

The lingual nerve.—The nerve is also a branch of the third division of the fifth.

It can be exposed as it lies underneath the mucous membrane of the floor of the mouth, about ½ inch below and behind the last molar tooth of the mandible, and also in the upper part of the incision which was described for ligature of the lingual artery (see p. 518). In the latter case the nerve will be found lying upon the hyoglossus, a short distance above the hypoglossal nerve.

Operation (through the mouth).—The patient is placed in the dorsal position, the mouth being held open with a gag, and the tongue drawn to the opposite side. The surgeon stands in front of the open mouth.

The nerve can be felt, generally, with the finger, as it lies underneath the mucous membrane. An incision about 1 inch in length is made through the mucous membrane on the floor of the mouth, in an antero-posterior direction, and situated about half-way between the side of the tongue and the inner surface of the jaw. With a blunt hook the nerve is lifted up from the connective tissue which surrounds it, and may be divided with a pair of scissors, or a small portion may be excised.

The facial nerve.—This nerve issues from the cranium through the stylomastoid foramen, and then passes downwards and forwards in the substance of the deep part of the parotid salivary gland. It can be exposed immediately beyond its point of emergence.

Position.—The patient lies on the back, with the head turned over towards the unaffected side. The surgeon stands on the affected side of the patient, and his assistant opposite him.

Operation.—An incision about 1½ inches in length is made, commencing above at the anterior margin of the mastoid process and opposite the external auditory meatus, and extending downwards to a point just behind the angle of the lower jaw. The skin, superficial and deep fasciæ are divided, and the anterior border of the sternomastoid and the posterior margin of the parotid gland exposed. The former is retracted backwards, and the latter forwards. On dividing the connective tissue between these two structures the posterior belly of the digastric muscle will become visible. This is drawn downwards, and then the facial nerve will be found in the upper part of the wound. In this position the nerve is surrounded by dense fascia, and careful dissection is necessary to expose it without injury. The posterior auricular artery and vein may be met with, in which case they are drawn aside with a retractor.

Anastomosis of facial and hypoglossal nerves.—*Indications.*—(*a*) Facial paralysis due to involvement of the facial nerve in disease of the petrous portion of the temporal bone, which is not amenable to local operation.

(*b*) Facial paralysis caused by division of the facial nerve in the temporal bone, either as the result of injury, or in the course of a surgical operation.

(*c*) Permanent facial paralysis following fracture of the base of the skull, and involving the petrous bone.

(*d*) Facial paralysis due to division of the facial nerve in the neck, in which, owing to the loss of substance, the two ends cannot be brought together, or in old-standing injuries in which, after excision of the scar tissue, approximation of the two ends cannot be effected.

It is very essential, in all operations of nerve anastomosis, that an aseptic course be ensured, otherwise the results will be unsatisfactory. Thus in cases of suppurative disease in the temporal bone the septic condition must be cured before the operation upon the nerves is attempted.

Position.—The patient is placed in the dorsal position, and the head turned towards the sound side and thrown slightly backwards.

Operation.—An oblique incision 3½ inches long is made on the antero-lateral aspect of the neck, which commences above on the anterior border of the mastoid process at the level of the external auditory meatus, and terminates below a short distance beyond and behind the angle of the mandible. The skin, fasciæ, and platysma are divided, and the anterior border of the upper portion of the sternomastoid exposed. This muscle is pulled backwards with a retractor, the cervical fascia on its deep aspect carefully cut through, and the posterior belly of the digastric muscle laid bare.

The upper border of the muscle is cleaned by dissection and then retracted downwards and backwards by an assistant. In muscular patients it may be necessary to cut through some of the uppermost fibres. With the finger the position of the styloid process in the upper and posterior part of the wound is defined, and if the parotid salivary gland is in the way it is pulled upwards and forwards with a retractor. The styloid process is traced upwards to its attachment to the skull, and the fascia at its base and in front carefully dissected away. In this tissue will be found the facial nerve as it passes out of the stylo-mastoid foramen. Immediately beyond the foramen it sinks into the substance of the parotid salivary gland.

By dissection the facial nerve is separated from the surrounding fascia, and if it has been injured or divided in the temporal bone, judicious traction may be exerted upon it to pull that portion of the nerve which lies beyond the division out of its bony canal. If this is not possible the bone forming the outer boundary of the stylo-mastoid foramen should be cut away and the nerve divided as high as possible with a fine sharp tenotome.

The position of the transverse process of the second cervical vertebra is next defined, with the finger in the bottom of the upper portion of the wound. Careful dissection is carried out in this region in order to expose the occipital artery as it runs across the transverse process of the epistropheus (O.T., axis). The position of the artery can often be made out by feeling the pulsation in it with the finger. The artery having been recognised, the internal jugular vein is next defined by dissection in the medial part of the wound and retracted medially by an assistant. The hypoglossal and vagus nerves will now be seen lying behind the vein; the former is recognised as it hooks round the occipital artery, and the latter as it passes vertically downwards in the carotid sheath.

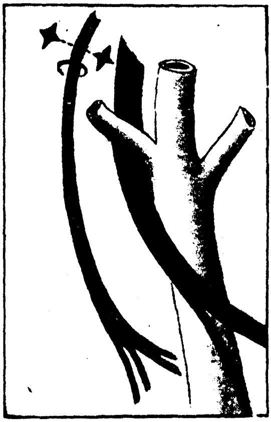

FIG. 408.—Facio-hypoglossal anastomosis. Nerves exposed and ready for establishment of an anastomosis.

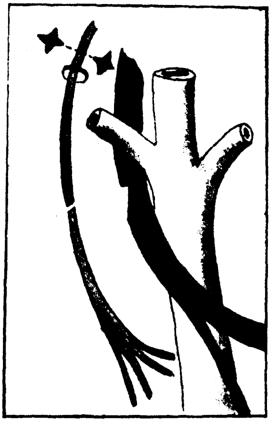

FIG. 409. — Facio - hypoglossal anastomosis. Facial nerve divided and hypoglossal nerve prepared for anastomosis.

The surrounding fascia is dissected from the region of the hypoglossal, and the nerve brought forwards so as to lie in close relation with the facial (Fig. 408).

If the two nerves come together without any tension, the peripheral end of the facial is divided obliquely with a sharp scalpel. Next, an oblique incision is made in the hypoglossal, about one-third of its fibres being divided (Fig. 409) and the two prepared nerve surfaces placed in apposition and fixed by the insertion of two points of interrupted suture of fine chromicised catgut (Fig. 410). If the two nerves do not come together without tension the hypoglossal is divided transversely for one-third of its thickness, and a flap of nerve lifted up by splitting. The peripheral end of the facial is divided transversely, and the two prepared surfaces brought together and fixed (Figs. 411, 412).

The deep parts of the wound are carefully sponged dry, any vessels which require it ligatured, and the external wound closed by sutures.

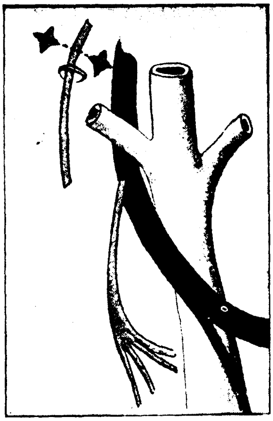

FIG. 410.—Facio-hypoglossal anastomosis. Anastomosis completed by suturing prepared surfaces together.

After-treatment.—The muscles supplied by the facial nerve should be massaged daily and treated electrically by the application of the constant current, until voluntary movements become established.

Results. — Improvement has resulted in nearly all cases operated upon in which no septic complications in the wound have occurred. When voluntary movements commence they are associated with movements of the tongue, but soon they become dissociated. Complete return of the movements of emotion does not appear to occur.

The accessory nerve.—The accessory nerve emerges from the cranium through the middle compartment of the jugular foramen in company with the vagus. From this point it passes in a downward and backward direction, crossing the internal jugular vein and below the transverse process of the atlas, until it reaches the anterior border of the deep portion of the sternomastoid muscle, which it enters at the junction of the upper with the second fourth. It emerges from this muscle a little below the junction of the upper with the middle third, and then crosses the posterior triangle to reach the trapezius, into the deep aspect of which it enters. The nerve can be exposed either before or after it pierces the sternomastoid muscle. The operation for exposure of the nerve is usually undertaken for wry-neck, in which case the nerve must be laid bare above the point at which it enters the sternomastoid.

Position.—The patient is placed in the dorsal position with the head and shoulders slightly raised by means of a pillow, and the head turned towards the unaffected side and thrown slightly backwards.

Operation.—An incision about 2½ inches long is made along the anterior border of the sternomastoid, commencing above at the apex of the mastoid process (Fig. 413). The skin, superficial fascia, and deep fascia are divided for the entire length of the incision, by which means the external surface of the sternomastoid is exposed. The anterior border of the muscle is defined, and the head is bent forwards a little so as to allow of retraction of the muscle and exposure of the fascial sheath behind. When this has been done the posterior part of the sheath is divided in the line of the original incision, and the nerve carefully sought for as it enters the muscle. The nerve can often be felt as a rounded cord immediately below and lateral to the transverse process of the atlas. If the nerve is not readily found the inferior border of the posterior belly of the digastric muscle should be defined, and the nerve sought for in the space between this muscle and the sternomastoid. The fascia in this region is dense, and careful dissection is necessary.

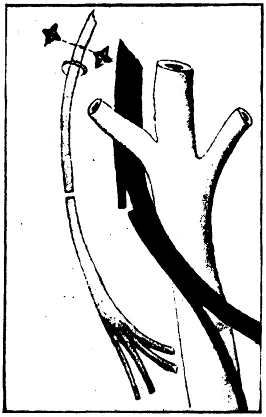

FIG. 411.—Facio-hypoglossal anastomosis. Facial nerve divided transversely across, and hypoglossal also transversely for one-third of its thickness, and then dissected up by splitting.

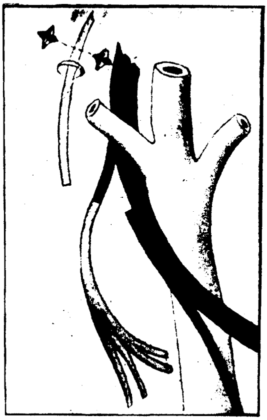

FIG. 412.—Facio-hypoglossal anastomosis. The facial nerve has been divided obliquely across, and the hypoglossal in a similar manner for one-third of its thickness.

Union of facial and accessory nerves.—*Indications.*—This operation has been adopted in some cases where a permanent destructive lesion of the facial nerve exists on the intracranial side of the stylo-mastoid foramen—the aperture of exit of the facial nerve from the skull; but better results are obtainable by anastomosis of the facial and hypoglossal nerves.

Operation.—An incision 2½ to 3 inches long is made, commencing at the apex of the mastoid process and extending downwards along the anterior border of the sternomastoid muscle. The facial and accessory nerves are sought for, as described in the two preceding operations, and the accessory nerve divided close to its entrance into the sheath of sternomastoid muscle posteriorly, then turned forwards and united to the facial nerve. The wound is then closed and dressed.

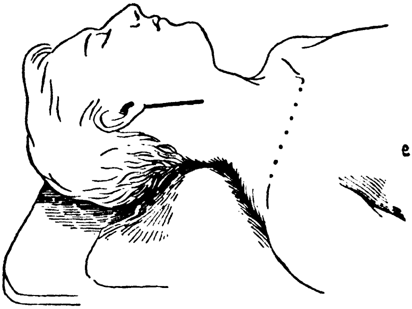

FIG. 413.—Exposure of accessory nerve.
Position of skin incision (spinal accessary, O.T.).

The great occipital nerve.—This nerve is a cutaneous branch of the posterior division of the second cervical, and passes into the scalp through the outer margin of the trapezius muscle where this is attached to the superior curved line of the occipital bone.

Operation.—The patient lies in the same position as for exposure of the accessory nerve, but with the head bent downwards towards the chest.

An incision about 1½ inches long is made parallel with the superior curved line of the occipital bone, commencing a short distance outside the external occipital protuberance. The skin and fasciæ are divided, and then the nerve will become visible lying above and internal to the interval between the sternomastoid and trapezius, and on the medial side of the occipital artery. If not readily exposed, it can be found usually by dissecting underneath the trapezius, when it will be seen issuing from the complexus. The surrounding fascia is very dense ; on this account care must be taken not to divide the nerve where it lies close to the bone.

The brachial plexus.—The brachial plexus lies in the posterior triangle of the neck and the upper part of the axilla, and extends as far as the apex of the coracoid process, where it terminates by dividing into its various branches. It is composed of the anterior primary divisions of the lower four cervical nerves, together with the greater part of the anterior division of the first dorsal, and a small branch from the fourth cervical. At its commencement it lies between the anterior and the middle scalene muscles.

Position.—The patient is placed in the dorsal position, with the shoulders raised, the head turned towards the unaffected side, and the arm drawn well down by the side of the body. The operator stands on the affected side of the patient, and the assistant on the opposite side.

Operation.—An incision about 3 inches in length is made, commencing above at the outer margin of the sternomastoid, at the level of the notch in the thyroid cartilage, and extending downwards to a point a short distance above the centre of the clavicle. The skin and superficial fascia with the platysma are divided, and the external jugular vein defined. It is necessary in most cases to ligature this vessel in two places, and divide it between, but occasionally it can be drawn aside. The deep fascia is next divided for the entire length of the incision, the supraclavicular nerves being avoided if possible. In the lower part of the wound the posterior belly of the omo-hyoid muscle will be exposed, and at the medial margin, the lateral border of the scalenus anterior, which corresponds at the upper part of the incision with the posterior border of the sternomastoid, lying more superficially. The former muscle is drawn downwards, and the fascia carefully separated from the cords of the plexus as they appear at the outer margin of the scalenus anterior. The superficial branch of the transverse cervical artery, and its accompanying vein, lie in front of the plexus in the outer part of the incision.

The radial (O.T., musculo-spiral) nerve. — This nerve is given off from the posterior cord of the brachial plexus opposite the coracoid process. From this point it first passes downwards behind the axillary artery, and at the upper part of the arm it begins to wind outwards in the groove for the radial nerve, in company with the profunda artery of the humerus. In the distal third of the arm it pierces the lateral intermuscular septum, and lies in front of the brachialis overlapped by the brachio-radialis (supinator longus). The nerve may be exposed in the groove for the radial nerve, and also in the distal third of the arm where it lies upon the brachialis.

(*a*) *In the groove for the radial* (*musculo-spiral*) *nerve.—Position.*—The patient lies in the dorsal position; the upper arm is placed vertically, the elbow is fully flexed, and an assistant holds the limb in this position (Fig. 414). The operator stands on the affected side, and his assistant at his left hand.

Operation.—An incision 3 inches in length is made in the middle third of the posterior aspect of the upper arm, parallel with the long axis of the limb (Fig. 414, *a*). The skin, superficial fascia, and deep fascia are divided for the whole length of the incision, and the triceps muscle exposed. This structure is divided in a vertical direction until the groove is reached, when the nerve will be found lying upon the bone in company with the profunda vessels. The nerve is separated from the artery, and may then be treated by whatever special method is thought advisable. If care is not taken in the later stages of the operation the nerve may be divided as it lies upon the humerus.

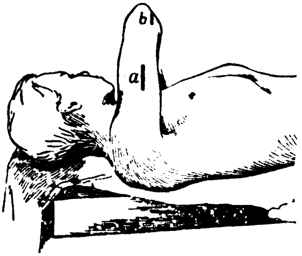

FIG. 414.—Position of patient, and lines of external incisions, in exposure of radial (musculo-spiral, O.T.) nerve in the groove for the radial nerve and of ulnar nerve behind the medial epicondyle of the humerus.

a. Radial. *b*. Ulnar.

(*b*) *In front of the arm above the bend of the elbow.—Position.*—The arm is placed at right angles to the side, supinated, slightly flexed at the elbow, and supported on a table.

Operation.—An incision is made about 3 inches in length immediately to the medial side of and parallel with the medial border of the brachio-radialis (supinator longus), commencing an inch above a point one-third of the distance from the lateral to the medial epicondyles of the humerus, and extending upwards parallel with the lateral margin of the biceps (Fig. 415, *a*). The skin and fasciæ are divided, and the fibres of the brachio-radialis (supinator longus) muscle exposed. This muscle is retracted towards the lateral side, when the nerve will become visible lying on the brachialis, a short distance below the point where it has pierced the lateral intermuscular septum. The musculo-cutaneous nerve is usually exposed lying upon the brachialis and is distinguished by its course downwards and laterally, in which case it is drawn aside with a retractor.

The ulnar nerve.—This nerve is a branch of the medial cord of the brachial plexus. In the proximal part of the arm it lies on the medial side of the brachial artery, but separated from it by the medial vena comes and some connective tissue. The course of the nerve in the arm is indicated by drawing a line from the coracoid process to a point half-way between the medial epicondyle of the humerus and the olecranon. The nerve passes behind the medial epicondyle and down the forearm to the radial side of the pisiform bone, beyond which point it enters the palm and divides into superficial and deep branches. Its course in the forearm is marked out by a line drawn from a point midway between the medial epicondyle and the olecranon, to the radial side of the pisiform bone. In this part of its course the nerve lies underneath the flexor carpi ulnaris, until it reaches the region of the wrist, where it becomes more superficial.

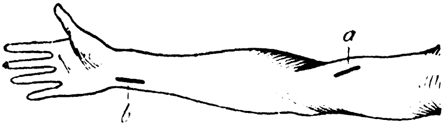

FIG. 415.—Position of limb, and lines of external incisions in exposure of radial (O.T. musculo-spiral) nerve above the bend of the elbow, and ulnar nerve at the wrist.

a. Radial. *b.* Ulnar.

1. *To expose the nerve in the middle of the upper arm.—Position.*—The patient is placed in the dorsal position, with the arm at right angles to the side, and supinated. The operator stands between the limb and the trunk, and the assistant on the outer side of the limb.

Operation.—An incision 2 inches in length is made in the middle third of the arm, parallel with the line of the brachial artery, and about ½ inch to its medial side (Fig. 416, *a*). The skin, the superficial fascia containing the basilic vein, and the deep fascia are divided, and the nerve exposed as it lies on the medial side of the medial vena comes of the brachial artery.

2. *To expose the nerve at the bend of the elbow.—Position.*—The patient is placed in the dorsal position, the affected arm is semiflexed at the elbow, and drawn across the chest so as fully to expose the posterior aspect of the bend of the elbow.

Operation.—An incision 1½ inches in length is made over the course of the nerve, the central point being half-way between the medial epicondyle and the medial margin of the olecranon (Fig. 414, *b*). This incision divides the skin and the superficial and deep fasciæ, and exposes the two heads of origin of the flexor carpi ulnaris muscle. The aponeurosis which connects these two heads is incised, and then the nerve will be found lying in the groove behind the medial epicondyle and upon the posterior ligament of the elbow-joint. If the incision is deepened too much the cavity of the elbow-joint will be opened. The ulnar artery is a considerable distance from the nerve in this region.

3. *To expose the nerve in front of the wrist.*—The position of the patient is the same as for exposure of the nerve in the upper arm, the hand being well supinated.

Operation.—An incision 1½ inches in length is made over the line of the nerve, commencing below on the radial side of the pisiform bone, and extending upwards on the radial side of the tendon of the flexor carpi ulnaris (Fig. 415, *b*). The skin and fasciæ are divided, and then the nerve will be visible, having the ulnar artery on its radial side.

The median nerve.—This nerve commences opposite the coracoid process by two heads, one from the medial and one from the lateral cord of the brachial plexus, and passes distally in the arm, lying first on the lateral side of the brachial artery, then in front of it, and finally on its medial side. At the bend of the elbow it is separated from the artery by the medial vena comes. The nerve next sinks between the two heads of the pronator teres, and then runs distally to the middle of the wrist, beyond which point it enters the palm and divides into its terminal branches.

Operation. — *In the arm.* — The nerve may be exposed in the arm by an incision which is the same as for ligature of the brachial artery (Fig. 363, *b*, p. 532).

2. *At the bend of the elbow.*—At the bend of the elbow it may be exposed by making an incision, 1½ inches in length, parallel with the long axis of the limb, the centre of the cut corresponding to a point one-third of the distance from the medial to the lateral epicondyle of the humerus (Fig. 416, *b*). The skin, superficial and deep fasciæ are divided, care being taken to avoid the superficial veins and the medial (internal) cutaneous nerve of the arm; the nerve will then be exposed as it lies on the brachialis to the medial side of the brachial artery, but separated from this by the medial vena comes. The deep fascia in this region is strengthened by the lacerta fibrosa (bicipital fascia) from the biceps.

3. *At the wrist.*—The median nerve may also be exposed in front of the wrist.

An incision 1½ inches in length is made, commencing below opposite the middle of the anterior aspect of the wrist, and extending proximally on the medial side of the tendon of the flexor carpi radialis (Fig. 416, *c*). When the skin and fasciæ and the upper fibres of the transverse carpal ligament have been divided, and the flexor digitorum sublimis has been retracted towards the medial side, the nerve will appear as a large rounded cord, somewhat pinkish in colour, lying to the medial side of the tendon of the flexor carpi radialis, and underneath the palmaris longus tendon when this is present. At this point the nerve is usually enlarged and fusiform in shape.

The sciatic nerve.—This nerve is the main continuation of the sacral plexus. It emerges from the pelvis below the piriformis muscle, and extends towards the popliteal space, ending by dividing into its two terminal branches, the common peronæal and tibial nerves. The point of division varies; in some cases the nerves are given off separately from the sacral plexus, and in others the division occurs in the proximal part of the popliteal space. The nerve lies upon the short lateral rotator muscles of the thigh, and lower down upon the posterior aspect of the adductor magnus. The glutæus maximus covers the nerve above and the hamstrings below. It is usually exposed immediately below the lower margin of the glutæus maximus.

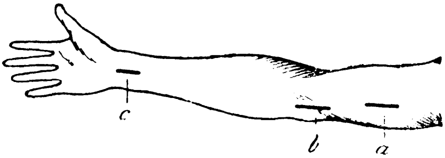

FIG. 416.

a. Incision to expose ulnar nerve in middle of arm.
b. Incision to expose median nerve at bend of elbow.
c. Incision to expose median nerve at wrist.

Position.—The patient lies on the sound side, with the affected lower extremity slightly flexed at the hip and knee. The surgeon stands opposite the exposed buttock, and the assistant on his left hand.

Operation.—An incision 3½ inches in length is made, commencing above a short distance below the midpoint between the ischial tuberosity and the top of the great trochanter, and extending vertically distally (Fig. 417); the skin, the superficial fascia in which in the distal part of the incision the posterior cutaneous nerve of the thigh (small sciatic) is contained, and the deep fascia are divided, when in the upper part of the wound the oblique fibres of the lower portion of the glutæus maximus will be exposed. These are retracted upwards, and then the hamstring muscles will be seen on the medial side of the incision. These structures are retracted inwards, and the bottom of the wound examined with the finger. The sciatic nerve will then be felt as it lies upon the adductor magnus, and can easily be lifted up in the wound and stretched. The nerve is returned, and the external wound closed in the usual manner.

The common peronæal (external popliteal) nerve.—This nerve runs along the lateral margin of the popliteal space on the medial side of the biceps tendon. It next pierces the posterolateral intermuscular septum, and lies upon the neck of the fibula, underneath the fibres of the peronæus longus muscle, where it divides into the deep peronæal (anterior tibial) and superficial peronæal (musculo-cutaneous) nerves. The nerve can be felt as a rounded cord lying upon the neck of the fibula, and also at the medial side of the biceps tendon, especially when the knee is extended.

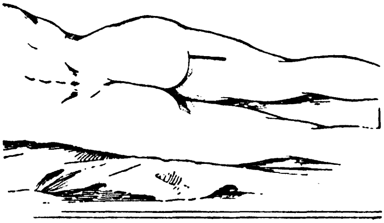

FIG. 417.—Incision for exposure of great sciatic nerve.

Position.—The patient lies on the sound side, with the affected limb slightly flexed at the hip and the knee, so that it rests on the sound one. The surgeon stands behind the limb to be operated upon, and his assistant opposite to him.

Operation.—An incision 2 inches in length is made, commencing above the lower border of the head of the fibula, and extending distally in the long axis of that bone. This incision divides the skin, superficial fascia, and deep fascia, and exposes the outer surface of the peronæus longus muscle. This muscle is divided for the entire length of the incision, and then the nerve will be exposed as it lies upon the bone. Care must be taken, when dividing the muscle, not to divide the nerve as well.

The deep peronæal (musculo-cutaneus) nerve.—This can be exposed from the front of the leg by an incision similar to that described for the corresponding artery (p. 559).

The tibial (O.T., internal popliteal nerve).—The tibial nerve can be exposed in the lower part of the popliteal space, through an incision similar to that for ligature of the popliteal artery in this region (p. 554).

The posterior tibial nerve.—This nerve runs down the leg in company with the corresponding artery, and it can be laid bare by operations similar to those described for the artery (pp. 556-8).

The femoral (O.T., anterior crural) nerve.—This nerve passes out from the pelvis through the muscular space beneath the inguinal ligament, lying upon the ilio-psoas muscle ½ inch to the lateral side of the femoral artery, from which it is separated by the ilio-pectineal ligament and a few fibres of the psoas muscle.

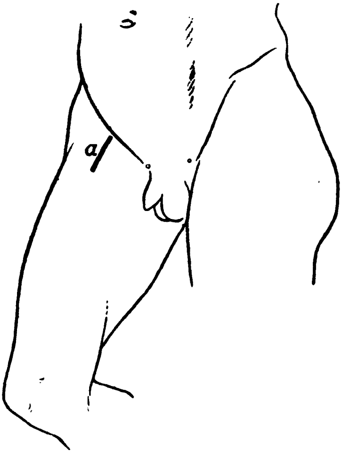

Fig. 418.—Incision to expose femoral (O.T., anterior crural) nerve.

Position.—The patient is placed in the same position as for ligature of the femoral artery.

Operation.—An incision 2 inches long is made ½ inch lateral to the artery, and parallel with it. The incision commences above at the inguinal ligament (Fig. 418). The skin, superficial and deep fasciæ are divided, and then the nerve may be found lying upon the ilio-psoas muscle, surrounded by a variable amount of fatty connective tissue. In many cases it is difficult to distinguish the nerve on account of this fat.

CHAPTER XXVI

OPERATIONS ON TENDONS, MUSCLES, LIGAMENTS, AND APONEUROSES

THE division of a tendon by a surgical operation is called tenotomy; that of a muscle, myotomy; of a ligament, syndesmotomy; whilst the term aponeurotomy has been applied to the division of a band of fascia.

These operations may be performed according to two distinct methods of procedure : in the first, the entire operation is carried out subcutaneously through a small skin incision ; and, in the second, an open wound is made so as to fully expose the structure which it is wished to divide. When an operation is performed according to the first of the above methods it is said to be done "subcutaneously," and when done according to the second "by the open method."

The subcutaneous method.—The advantages of this operation are—(*a*) The small wound which is necessary, and the avoidance of a scar ; (*b*) the less risk run of the wound becoming infected with the micro-organisms of suppuration—a risk which under modern methods is quite negligible. The disadvantage is, the fact that the surgeon is working somewhat in the dark, and important structures in the region of the field of operation may be injured, or the tendon which it is proposed to divide may be missed altogether. The subcutaneous method has been displaced to a considerable extent by the open method.

The open method.—When performing an operation by this method, an incision, large enough fully to expose the anatomical structure which it is wished to deal with, is made in the situation required. The advantages of this method of procedure are the free exposure of the tissue or structure which is it intended to operate upon, and the lesser liability to injure the adjacent structures ; whilst the disadvantages are the resulting scar and the dangers of sepsis. With the precautions which ought now to be adopted in all surgical operations the last objection need not be taken into serious consideration. In those cases in which the tendon, muscle, or ligament is deeply placed, or is in close relation with important anatomical structures, it is advisable to adopt the open method; but in cases in which the tendon is easily defined and separated from its surroundings, the subcutaneous method is preferable, and should be made use of.

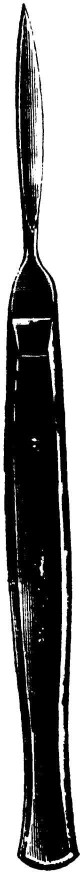
Fig. 419.—Sharp-pointed tenotome.

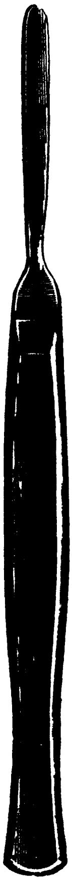
Fig. 420.—Blunt-pointed tenotome.

Special instruments.—When performing an operation by the subcutaneous method, two special knives called tenotomes are requisite, one having a sharp point and the other a blunt one (Figs. 419 and 420); whilst for the open operation the ordinary instruments for a "cutting operation" are necessary.

Method of operating.—In performing an operation by the subcutaneous method a point in the course of the tendon is selected which lies, if possible, above or below any synovial sheath, and in the same side of the tendon as the most important anatomical structure which might be exposed to injury, and which may thus be more certainly avoided. The sharp tenotome is then pushed inwards so as to pass behind the structure which it is intended to divide, the tendon being slightly stretched so that its position can be defined. The blade of the tenotome is introduced "on the flat," *i.e.* with the transverse axis of the blade parallel with the long axis of the tendon, and the tissues are divided sufficiently to allow the blunt instrument to be easily introduced. The sharp tenotome is withdrawn, and the blunt-pointed one passed in through the original skin puncture with the blade " on the flat." When it has been introduced the cutting edge is turned towards the tendon, the tendon itself is made tense by the assistant holding the limb, and the structure is divided with a sawing movement, care being taken not to enlarge the skin puncture. The index-finger of the surgeon's left hand is held over the tendon where it is being divided, so that the movements of the instrument can be felt, and cutting through the skin avoided.

In a few cases, such as the division of bands of contracted fascia which lie near the surface of the skin and away from any important structure, the entire operation can be completed with the sharp tenotome, but in nearly all other cases it is much safer to use the blunt-pointed instrument as well.

SPECIAL OPERATIONS

Tenotomy of the sternomastoid.—The sternomastoid muscle is attached by two heads of origin, one—tendinous—to the anterior aspect of the manubrium sterni, and the other—muscular—to the superior border of the medial third of the clavicle. It is enclosed within a sheath of deep cervical fascia. Along the inner border of the sternal head lies the anterior jugular vein, and in relation with the clavicular head lies the external jugular vein. The carotid sheath with its contents is situated immediately under cover of the muscle, but portions of the sternohyoid and sterno-thyroid muscles intervene. The two heads of the muscle are divided separately, through different incisions.

Position.—The patient is placed in the dorsal position, with a pillow underneath the shoulders, and with the head projecting slightly beyond the top of the table. The head is rotated towards the unaffected side by an assistant, who holds it in this position so as to keep the muscle on the stretch.

The surgeon stands upon the affected side of the patient, and the assistant on the opposite side.

Operation.—*Subcutaneous operation.*—An incision with the point of a sharp tenotome is made at the medial border of the sternal head of the muscle, about one-third of an inch above the sternum, and deepened until the deep fascia has been divided and the tendon of the muscle exposed. The sharp instrument is then withdrawn, and the blunt one introduced. The tenotome is now carefully pushed behind the tendon, with the blade "on the flat," until it can be felt in the interval between the two heads of the muscle. The cutting edge of the knife is now turned towards the skin, and the muscle divided with a slight sawing movement. The forefinger, during the division of the tendon, is kept over the skin in front of the field of operation. The clavicular head of the muscle is next divided

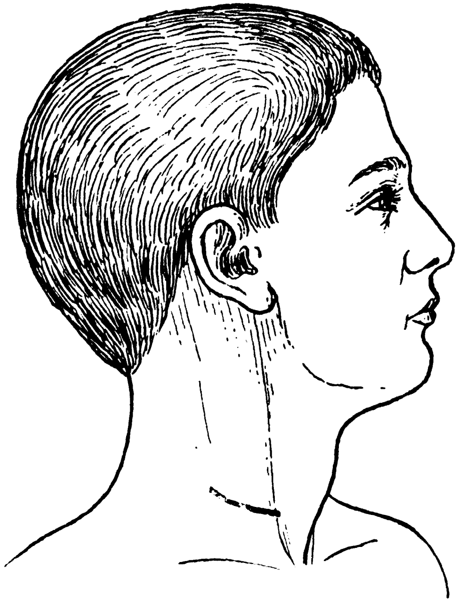

FIG. 421.—Position of incision in "open operation" for division of sternomastoid.

in a similar manner, by entering the tenotome at the lateral border of the muscle, about one-third of an inch above the clavicle. Care must be taken in this part of the operation not to injure the external jugular vein.

On account of the close proximity of important structures, it will generally be advisable to divide the sternomastoid only through an open incision.

Open operation.—An oblique or semilunar incision in one of the natural creases or folds of the lower portion of the neck is made over the lower portion of the sternomastoid muscle about ¾ to 1 inch above the sternal end of the clavicle, and in the position shown in Fig. 421. The skin and fascia are cut through until the surface of the muscle is exposed, care being taken to avoid the external jugular vein and its tributaries. Next, the substances of the muscle is divided until all the contracted part has been severed. When this has been done, the fibres of the muscle generally contract and a space appears within the sheath of the muscle and between the divided extremities. This is sponged dry and any tight or resisting bands of fascia cut through with scissors. This proceeding must be carried out very carefully, in order to avoid the jugular vein which lies underneath. Finally, the external wound is closed by fine sutures of salmon gut or a subcuticular suture of catgut.

The adductor longus.—This tendon may be divided a short distance below its attachment to the body of the os pubis.

Position.—The lower extremity is placed in a position of semiflexion, abduction, and external rotation.

The surgeon stands on the outer side of the limb to be operated upon, and the assistant on the opposite side.

Operation.—The lateral margin of the tendon is defined about ½ inch below the pubic spine, and the sharp tenotome introduced. When an aperture has been made the blunt instrument is introduced, and the tendon divided by cutting towards the surface. A small branch of the superficial pudendal artery may be injured, but usually the tendon is divided below this vessel.

The biceps femoris.—The tendon of the biceps femoris is usually divided a short distance above its insertion into the head of the fibula.

Position.—The patient lies as far as possible on the sound side.

The operator stands behind the patient, and the assistant on the other side.

Operation.—*Subcutaneous operation.*—The position of the tendon is defined about an inch above the head of the fibula, along the lateral border of the popliteal space. A point is selected on the medial margin of the tendon, and with the thumb of the surgeon's left hand the common peronæal (external popliteal) nerve is separated from the tendon. The sharp tenotome is then taken, and a small puncture made which extends down to the surface of the tendon. The sharp tenotome is withdrawn, and the blunt one introduced. The handle of this instrument is depressed, and the blade insinuated underneath the tendon, which is then divided by cutting laterally with a sawing movement. It is possible to mistake the ilio-tibial band of the fascia lata for the tendon of the biceps muscle.

In order more certainly to avoid the common peronæal nerve, it is best to conduct this operation through an incision parallel to the biceps tendon, by the open method.

Open operation.—The tendon having been defined by palpation, an incision about three quarters of an inch in length is made directly over the tendon and in a vertical direction, the tendon being rendered taut by an assistant, who extends the limb at the knee. When the tendon has been exposed, the soft structures are dissected away from it, on each side and on the deep aspect: the tendon having been thus cleared, the nerve is protected on its deep aspect and then division is effected with the scalpel, transversely when the object of the operation is simple tenotomy and obliquely when tendon lengthening is desired. In the latter case the incision should be 2 inches or even more in length. The interior of the wound is next investigated with the finger in order to detect any tense bands of fascia. These are cut through after the margins of the wound have been retracted. All bleeding points are then sought for and ligatured, and finally the external wound is closed.

The semitendinosus and semimembranosus.—The tendons of these muscles may be divided by a procedure similar to that for the division of the biceps. They lie on the medial side of the popliteal space, and the semitendinosus is divided about 1 inch above the level of the knee-joint, the semimembranosus ½ inch. The tenotome is entered on the lateral side of the tendons. The tibial nerve lies near the middle of the popliteal space, and is not likely to be injured.

The tendo calcaneus (O.T., Achilles).—The tendo calcaneus is the tendon of insertion of the soleus and gastrocnemius muscles, and is attached to the prominence of the calcaneus (os calcis). The narrowest portion of the tendon is situated about 1½ inches above its insertion, and it is at this point that the tendon is divided.

Position.—The patient is placed in the dorsal position, but lying somewhat on the side of the affected limb; the leg is allowed to project a short distance beyond the end of the table, and is turned on its lateral side so as fully to expose its medial aspect.

The surgeon stands on the outer side of the foot, and the assistant opposite to him, holding the foot with one hand and the leg with the other.

Operation.—*Subcutaneous.*—The tendon is slightly stretched, so as to render its position definite, and the sharp tenotome entered at its tibial margin about 1½ inches above the heel.

The tenotome is made to pass in front of the tendon until it can be felt at the fibular margin. The sharp instrument is withdrawn and the blunt one introduced. The cutting edge is turned towards the tendon, and the foot dorsiflexed by the assistant, so as to make the tendon quite tense. The tendo calcaneus is now cut through with a slight sawing movement, the forefinger of the surgeon's left hand being held over the portion of the tendon which is being divided, so as to guard against injury of the overlying skin. Care must be taken to divide the entire tendon. It sometimes happens that the tenotome is passed through the tendon itself, if the convexity forwards of the tendon is not remembered, in which case only the superficial part will be divided.

Tenotomy of tendo calcaneus (Achilles) by the lengthening method.—This method of tenotomy is particularly desirable in adults because the amount of lengthening of the tendon can be accurately controlled.

Position.—The patient is placed in the dorsal position with the foot projecting slightly beyond the edge of the table.

Operation.—A sharp tenotome is introduced to the medial side of the tendon immediately above its insertion into the calcaneus (os calcis). The sharp edge of the knife is turned outwards and by a sawing movement the tendon is cut halfway through. The tenotome is now withdrawn and re-introduced in the lateral side of the tendon, about 2 inches above its insertion. The tendon is slowly cut towards its medial side until with steady pressure on the sole of the foot the tendon is felt to begin to give. The tenotome is then removed, and by continued pressure on the foot the tendon is stretched to the required length. Finally the foot is put up in plaster of Paris.

The tendon of the tibialis anterior.—This tendon lies in the most medial compartment of the anterior annular ligament of the ankle-joint, and it has a separate synovial sheath, which extends upwards about 1 inch or 1½ inches above the ankle-joint, and downwards to within 1 inch of the insertion of the muscle into the medial side of the first cuneiform and the base of the metatarsal bone of the great toe.

The tendon is usually divided immediately below the synovial sheath, that is to say, not quite 1 inch above the insertion, and as it lies in relation with the navicular. It is separated from the dorsalis pedis vessels by the extensor longus hallucis.

Position.—The surgeon stands on the outer side of the leg, which should project over the end of the table, the patient lying in the dorsal position. The assistant stands opposite, holding the foot with one hand and the leg with the other. The foot is abducted and plantar-flexed, by which means the tendon is made tense, and can easily be defined.

Operation.—The tenotome is entered on the lateral side of the tendon, a short distance in front of the prominence of the navicular, and is made to pass underneath the tendon until it can be felt at the medial margin. The tendon should be somewhat relaxed as the tenotome is being introduced. When a way has been made for the blunt instrument with the sharp one, the latter is withdrawn and the former introduced. The cutting edge is turned towards the tendon, and the tendon again made tense and divided from behind forwards, the surgeon's left forefinger being placed over the skin so as to act as a guide and prevent his cutting through to the surface.

The tendon of the tibialis posterior.—The tendon of the tibialis posterior occupies the medial compartment of the internal annular ligament of the ankle-joint, and is surrounded by a synovial sheath, which extends upwards for about 1 inch above the tip of the medial malleolus. The tendon of the flexor digitorum longus lies in the next sheath, and separates it from the posterior tibial vessels and nerve.

The tendon is usually divided above the synovial sheath, that is, immediately above the base of the malleolus.

Position.—The patient lies in the dorsal position, with the foot held in a position of slight dorsiflexion and abduction, and placed upon the fibular side. The surgeon stands on the outer side of the limb, and the assistant, opposite to him, holds the foot in the required position.

Operation.—The posterior border of the medial malleolus is defined and traced upwards until the part of the shaft above the base of the malleolus is reached. This point in the adult is about 1½ inches above the tip of the malleolus, but in young children it is not more than two-thirds of an inch above. When this point has been defined and the tendon felt, the foot is relaxed and the postero-medial border of the bone fixed with the thumb of the surgeon's left hand. The sharp tenotome is now passed upwards in a vertical direction between the tendon and the bone, and moved laterally so as to make a passage for the blunt instrument. When this has been done, the blunt tenotome is introduced and the cutting edge turned towards the tendon. The tendon is next made tense by again dorsiflexing and abducting the foot, and divided in the usual manner. As the last fibres of the tendon are being divided the foot is again relaxed by the assistant. If the tenotome is passed too deeply it occasionally happens that the posterior tibial vessels are injured. If this accident should occur, pressure by means of a pad and bandage must be applied at once. In many cases the tendon of the flexor digitorum longus is divided as well.

The tendons of the peronæi.—These tendons lie behind the lateral malleolus in a common groove, the peronæus longus being superficial and the peronæus brevis deep. They are surrounded in this position by a common synovial sheath, which extends upwards for about 1 inch above the base of the malleolus, and subdivides below into two portions, one for each tendon. The tendons are generally divided in the leg a short distance above the termination of the synovial sheath.

Position.—The patient lies on the sound side, with a sandbag placed underneath the distal third of the leg, and with the foot dorsiflexed and adducted. The foot rests on its medial aspect, the fibular surface being in front of the surgeon. The operator stands behind the affected limb, and the assistant, opposite to him, holds the leg steady in the position mentioned.

Operation.—The posterior border of the lateral malleolus is traced upwards, and a point selected about 1½ inches above the apex of the malleolus. The sharp tenotome is entered at this spot (the tendons being relaxed at the time), and made to pass inwards between the bone and the tendons. The sharp instrument is withdrawn, the blunt one introduced, and its edge turned away from the bone. The tendons are then rendered tense, and divided in the usual manner. The short saphenous nerve and vein are behind the tendons at the level of the point of division, and do not run any risk of being wounded if the above directions are adhered to.

The tendon of the extensor hallucis longus.—This tendon lies in a separate compartment underneath the anterior annular ligament of the ankle-joint, surrounded by a distinct synovial sheath. The tendon is situated on the lateral side of the tibialis anterior, and between it and the dorsal vessels of the foot. The tendon is divided a short distance below the bend of the ankle.

Position.—The patient lies in the dorsal position, with the affected foot projecting beyond the end of the table, where it is held in plantar-flexion by the hands of an assistant. The operator stands on the outer side of the foot.

Operation.—A point on the lateral side of the tendon is selected about 1 inch below the bend of the ankle, and with the thumb of the surgeon's left hand the dorsal vessels are held well away from the seat of operation. The tenotome is entered on the lateral side of the tendon, and passed medially until its point can be felt between it and the tibialis anterior. The sharp tenotome is then replaced by the blunt one, and the tendon divided in the usual manner. There is no risk of injuring the dorsal vessels if they are protected with the thumb of the left hand.

The tendons of the extensor digitorum longus and peronæus tertius.—These tendons lie in the same compartment of the anterior annular ligament of the ankle-joint, and are surrounded by the same synovial sheath. The dorsalis pedis vessels lie on the medial side. The tendons are divided 1 inch below the ankle-joint.

Position.—The position of patient and assistant are the same as for the preceding operation, but the surgeon stands on the tibial side of the affected limb.

Operation.—The dorsal vessels are protected with the surgeon's left thumb, and the tenotome entered on the medial side of the tendons. The tendons are divided by cutting laterally towards the skin.

Division of the plantar aponeurosis.—The plantar aponeurosis is divided in certain cases of talipes, and in most instances it is the central portion which requires attention. This part is attached posteriorly to the medial tuberosity of the calcaneus, while anteriorly it divides into five bands which pass to the toes. The fascia is usually divided in several places, the first point of division being a short distance in front of the calcaneus.

Position.—The patient is placed in the dorsal position, with the affected limb raised by placing a pillow or sandbag underneath the leg. The surgeon stands on the outer side of the foot, and the assistant opposite him. The foot is grasped by the hands of the assistant and dorsiflexed, the toes being extended so as to make tense the bands of fascia.

Operation.—A fine sharp-pointed tenotome is taken, and the blade passed between the skin and the contracted band of fascia, from whichever side is the more convenient. The cutting edge is turned towards the sole, and the fascia divided by cutting inwards. It is better to make several punctures and divisions of the fascia than completely to divide it through one incision.

Steindler's Operation.—In the majority of cases of pes cavus division of the plantar fascia alone is not sufficient to enable the surgeon to straighten the foot. All the structures attached to the under surface of the calcaneus (os calcis) must be separated from their attachment—these are the plantar fascia, abductor hallucis, flexor brevis digitorum, abductor minimi digiti, quadratus plantar (accessorius) and the long and short plantar ligaments.

Special instruments.—Sharp rugine and elastic tourniquet.

Position.—The patient is placed in the dorsal position and an elastic tourniquet is applied to the leg. The leg is somewhat flexed and laid on its outer side with the foot supported by a sandbag. The surgeon stands at the opposite side of the table.

Operation.—An incision is made starting at the back of the heel and continued forwards on the inner margin of the foot and the level of the mid-tarsal joint, running parallel with, and three-quarters of an inch above, the margin of the sole. A flap is turned downwards consisting of the skin and subcutaneous tissue of the heel. The posterior attachment of the plantar aponeurosis and the abductor hallucis are separated from the calcaneus (os calcis) with the knife, the sharp edge of which is kept close to the bone. The remaining muscles and ligaments can be separated with a sharp rugine or with a knife. The separation must be continued forwards until the calcaneo-cuboid joint is opened. The foot can now be straightened without difficulty. The skin flap is sutured, a firm dressing applied, and then the tourniquet is removed.

Division of the palmar aponeurosis (operation for Dupuytren's contraction).—Dupuytren's contraction consists in a pathological shortening of the bands of the palmar fascia passing to the fingers. For the relief of this condition two operations, the *subcutaneous* and the *open,* are practised.

Subcutaneous operation.—The affected hand is placed in a position of supination. A fine sharp-pointed tenotome is used, and passed on the flat into the tissues between the skin and the contracted band of fascia, and the attachments of the latter to the skin divided. The cutting edge of the blade is then turned through an angle of 90°, and the band of fascia severed by cutting away from the surface. It is necessary to divide the fascia in several places, and when the division is being made the fingers should be stretched by an assistant, so as to render the bands tense and distinct. Care must be taken not to allow the point of the tenotome to pass too near the margin of the finger, otherwise the digital vessels and nerves may be damaged. The points of puncture should be selected where the bands of fascia are least adherent to the overlying skin.

Open operation.—The hand is held in the same position as for the subcutaneous operation. A vertical incision is made through the skin and superficial fascia of the affected finger and the adjacent portion of the palm. This incision commences in the palm above the commencement of the contraction, and extends along the middle line of the affected finger to a point well beyond the contraction. The incision is deepened until the deep fascia is reached, and then the skin and superficial fascia are dissected up on each side. By this means the contracted bands of the palmar fascia are exposed. These are divided transversely, and are then, as far as possible, removed. It is requisite in this operation to have the tissues of the hand rendered bloodless by the application of a Martin's bandage of red rubber. When the contracted bands have been separated, divided, and removed the bandage is taken off, and if any bleeding points can be seen they are ligatured. The margins of the skin wound are next brought into exact apposition, and united with fine sutures of horse-hair or salmon-gut. The limb is put up on a splint with the fingers fully extended.

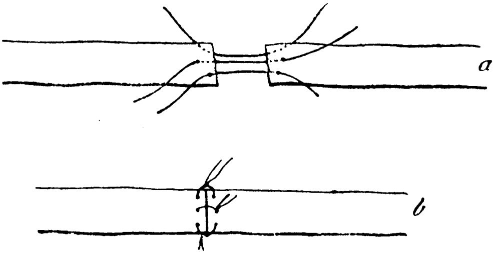

FIG. 422.—Suture of divided tendons.

a. Ends pared and sutures inserted. *b.* Sutures tied.

When a case of Dupuytren's contraction is treated by the subcutaneous method it is necessary to apply splints very carefully, and to see that they are worn for some considerable time, so as to prevent the return of the original condition. A useful form of apparatus for these cases is a glove, the backs of the fingers of which are lined by small curved steel plates; these should be worn at night, and may be left off during the day if requisite. The open operation is a more severe one, but if precautions are adopted to avoid the occurrence of septic processes the duration of treatment is much shorter than with the subcutaneous method, and a recurrence is not so likely to take place. In severe cases of Dupuytren's contraction good results may be obtained by excising an area of skin with the subjacent fascia, and covering the bare area with Thiersch grafts.

Division of the talo-navicular (astragalus-scaphoid) ligaments (syndesmotomy).—In this operation the ligaments which form the connection between the talus (astragalus) and navicular (scaphoid) are divided by a subcutaneous operation.

Position.—The patient lies in the dorsal position, with the foot placed upon its outer side.

The surgeon stands on the medial side of the foot, with an assistant opposite him, who holds the foot firmly in position.

Operation.—A point is taken a short distance below and in front of the apex of the medial malleolus, and just behind and above the tuberosity of the navicular. The sharp-pointed tenotome is introduced at this point, and pushed forwards and inwards until a point on the medial side of the dorsal vessels is reached. It is then withdrawn, and a special form of curved tenotome passed in along the tract which has been made. The cutting edge of this instrument is turned towards the bones, the foot is fully plantar-flexed so as to render the ligaments and tendons tense, and then the knife is withdrawn ; as this is being done it is made to cut all the structures down to the bone, the tendon of the tibialis posterior being divided just before the point emerges. The foot is then put up in the corrected position.

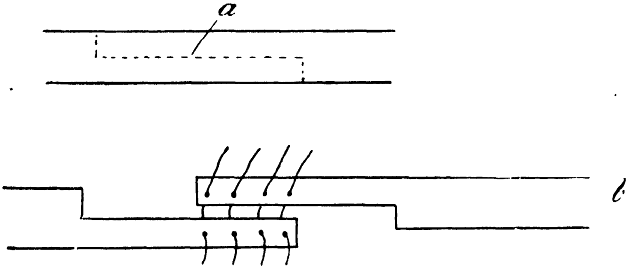

FIG. 423.—Lengthening of tendons. By a vertical incision.

a. Line of incision in tendon.
b. The two portions separated for a distance and sutures inserted.

This operation has been done in a considerable number of cases of congenital talipes varus, and with a fair amount of success.

Suture of divided tendons.—Tendons frequently require to be joined together when they have been partially or completely severed as the result of injury, as after incised wounds in the region of the wrist.

Operation.—The first part of the operation is the free exposure of the divided ends of the tendon. In order to do this it is often necessary to enlarge the wound in a proximal direction, since the muscles may contract and draw the proximal end of the tendon up within the tendon sheath.

The severed ends of the tendon having been exposed, the free extremities, if lacerated, are trimmed with scissors and brought into apposition.

With a fine needle the tendon is transfixed, as in Fig. 423, and sutures inserted. When all the necessary sutures have been introduced, each one is tied and the ends cut short. The external wound is then closed in the usual manner.

The limb is placed on a suitable splint, and maintained in a quiescent state until the approximated ends have had time to unite.

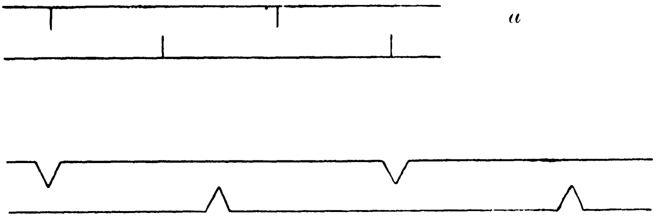

FIG. 424.—Lengthening of tendons. By alternate transverse incisions.

a. Position of alternate incisions.
b. Appearance of a tendon when lengthened and the margins of the incisions have separated in a V-shaped manner.

When it is impossible to find the proximal end of the divided tendon, or to bring the two extremities into apposition, the distal end may be implanted on the lateral aspect of one of the adjacent tendons, preferably one of a muscle which has an action similar to the one divided, or an attempt may be made to lengthen the tendon, as in the next operation.

When implantation is attempted, the lateral aspect of the tendon on which the severed extremity is about to be fixed is refreshed before the insertion of the sutures. This lateral implantation has been adopted in the case of paralysis of the gastrocnemius and soleus, the tendon of the peronæus longus being divided and joined on to the tendo calcaneus.

Lengthening tendons.—Lengthening of one or more tendons may be requisite under the following conditions:

(*a*) In some cases of severed tendons, in which the cut ends cannot be readily approximated.

(*b*) When a portion of tendon is removed, as in the extirpation of a malignant growth, and the ends cannot be brought together.

(*c*) In some cases of congenitally contracted tendons, where it is not wished to divide the tendon completely across.

(*d*) After sloughing of a portion of a tendon.

Operation.—Two methods of lengthening a tendon are practised :—

1. *By a vertical incision.*—The tendon which it is wished to lengthen having been exposed, an incision is made in its long axis, as in Fig. 423, *a*. The two portions are separated as in Fig. 423, *b*, and fixed together by the insertion of a number of fine sutures of silk, which transfix both parts of the tendon. The severed surfaces of the tendon thus lengthened are united, and then it is replaced in its normal position, the fascia sewn over it, and the external wound closed. A splint is applied so as to prevent movement of the affected part of the limb, and kept in position until the parts have become joined. Two or three weeks are usually sufficient for the purpose.

2. *By alternate transverse incisions.*—The tendon having been exposed, a number of transverse incisions placed alternately on each side of the tendon are made, after the method illustrated in Fig. 424, *a*. Each incision ought not to divide more than one-half the thickness of the tendon.

When the incisions have been made and the tendon stretched, the latter has the appearance shown in Fig. 424, *b*. The limb is fixed in the rectified position by a splint, as in the preceding operation.

The former of these two operations is the preferable, since better results are obtained.

Tendon Transplantation for Wrist Drop.—*Special instruments.*—Periosteal elevator. Blunt hook.

Position.—The patient lies in the dorsal position with the forearm supported on the armpiece of the operation table or on a side table. The surgeon sits at the lower end of this table and the first assistant stands opposite him. A second assistant, whose duty is to manipulate the fingers as required by the surgeon, is an advantage.

Operation.—The operation can be divided into four stages : first, transplantation of the pronator radii teres into the extensor carpi radialis longior and brevior ; second, exposure and division of the flexor carpi radialis and flexor carpi ulnaris ; third, exposure of the extensors of the wrist and digits at the back of the wrist ; fourth, anastomosis of the flexor carpi radialis with the abductor longus pollicis (extensor ossis metacarpi pollicis) and the extensor brevis pollicis (extensor primi internodii pollicis) and anastomosis of the flexor carpi ulnaris with the extensor longus pollicis (extensor secundi internodii pollicis).

1. *Anastomosis of the pronator radii teres to the extensor carpi radialis longior and brevior.*—A vertical incision 3 inches long is made over the middle of the radial side of the forearm. The skin and fasciæ are divided and the brachio-radialis (supinator longus) is exposed. The posterior border is sought and the whole muscle retracted forwards exposing the pronator radii teres above its insertion into the radius and the extensor carpi radialis longior and brevior in the back of the wound. The periosteum around the insertion of the pronator radii teres is incised and the muscle separated from the bone with a periosteal elevator, care being taken to avoid injury to the radial artery and nerve which lie on the flexor aspect of the insertion of the muscle. With the wrist fully extended the tendons of the extensor carpi radialis longior and brevior are pulled up and a small slit is made through each with a scalpel. A Kocher forceps (Fig. 425) is passed first through the extensor carpi radialis brevior and then the extensor carpi radialis longior and the cut tendon of the pronator radii teres is seized and drawn through the tendon and fixed to each with a couple of sutures. The wound in the skin and fasciæ is now closed with interrupted sutures of silkworm-gut.

2. *Separation of the tendons of the flexor carpi radialis and flexor carpi ulnaris.*—A vertical incision 1½ inches long is made over the middle of the flexor aspect of the wrist. The tendon of the flexor carpi radialis is identified and divided immediately above the anterior annular ligament. A third incision of equal length is made over the middle of the flexor aspect of the fasciæ and the cut tendon of the flexor carpi radialis is drawn through the wound by traction with a blunt hook. A fourth incision 3 inches long is made over the medial border of the flexor aspect of the forearm extending down to the wrist joint. Through this incision the flexor carpi ulnaris is identified and divided near its insertion into the pisiform bone. The exposed portion of the tendon is separated from the muscle fibres which are inserted into its lower portion.

3. *Exposure of tendons in back of wrist joint.*—The forearm is now pronated. A curved incision is made starting at the middle of the back of the wrist and continued with its convexity outwards to the radius about 2 inches above the styloid process, and then prolonged up the lateral border of the radius for 1 or 2 inches. In this incision are exposed from without inwards

the tendons of the abductor longus pollicis (extensor ossis pollicis), extensor brevis pollicis (extensor primi internodii pollicis), extensor carpi radialis longior and brevior, extensor longus pollicis (extensor secundi internodii pollicis), extensor indicis, extensor communis digitorum, extensor quinti digitis (ex. minimi digiti).

4. *Anastomosis of flexor carpi radialis and flexor carpi ulnaris to the digital extensors.*—Through the top and lateral corner of the wound in the dorsum of the forearm a Kocher forceps is passed subcutaneously to the wound in the middle of the forearm, and the tendon of the flexor carpi radialis is seized and drawn back to the dorsal wound. With the thumb fully extended and abducted, slits are made in the tendons of the abductor longus pollicis (extensor ossis metacarpi pollicis), and the extensor brevis pollicis (extensor primi internodii pollicis) and the tendon of the flexor carpi radialis is drawn successively through the slit tendons and sutured to each, care being taken to see that each tendon is taut. The Kocher forceps is now passed subcutaneously from the lower inner corner of the dorsal wound to the wound on the ulnar border, and the tendon of the flexor carpi ulnaris is passed successively through the slits made in the tendon of the extensor quinti digiti (extensor minimi digiti), extensor communis digitorum, extensor indicis, and extensor longus pollicis (extensor secundi internodii pollicis). The flexor carpi ulnaris is sutured to each of the pierced tendons whilst the fingers are kept extended, and the hand fixed in a cock-up splint with the fingers extended and the thumb extended and abducted.

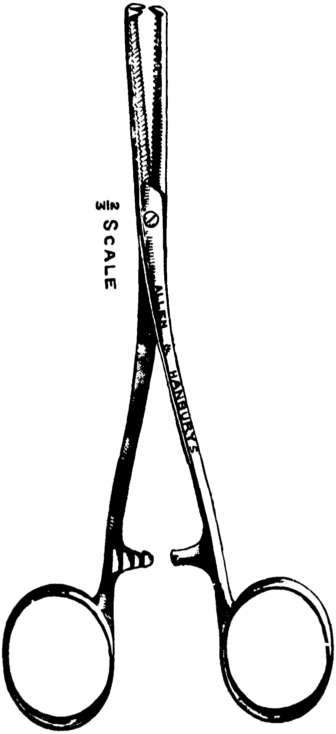

FIG. 425.—Kocher's forceps for use in operation upon tendons.

CHAPTER XXVII

OPERATIONS ON THE BONES

OSTEOTOMY.
OPERATIONS FOR FRACTURES.
EXCISION OF BONES.

Osteotomy.—By the term osteotomy is understood complete division of a bone in its continuity. Two forms of this operation are practised:—

(*a*) *Linear osteotomy.*—In this procedure a bone is divided transversely, usually through a small skin incision, the operation being more or less of the nature of a subcutaneous one.

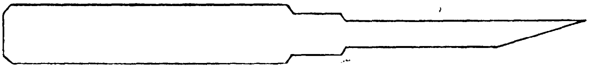

FIG. 426.—Chisel. Cutting edge.

(*b*) *Wedge-shaped or cuneiform osteotomy.*—In this operation, in addition to the division of the bone, a wedge-shaped portion is removed.

The operation of osteotomy is required in the majority of instances for the rectification of a congenital or acquired malformation of one or more bones, or for ankylosis of a joint in a bad position. The former condition is usually the result of rickets, or of union of a bone in a faulty position after it has been fractured.

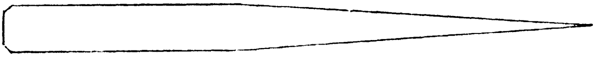

FIG. 427.—Osteotome. Cutting edge.

Special instruments.—Long-bladed narrow scalpel, chisel, osteotomes, mallet, suitable splints.

In certain cases pressure forceps and retractors may be required, and occasionally some form of saw.

In linear or transverse osteotomies an osteotome is used for division of the bone ; in wedge-shaped osteotomy a chisel will be found more convenient for the purpose. Figs. 426 and 427 show the shape of the cutting edge of a chisel and osteotome respectively.

Osteotomy of the distal extremity of the femur.—*Indications.*—(*a*) Those forms of genu valgum dependent upon malformation of the femur, which are not readily amenable to rectification by instruments, splints, or other means.

(*b*) Some cases of genu varum associated with malformation of the lower end of the femur.

(*c*) Occasional cases of malformation of the distal end of the femur, resulting from injury or after fractures.

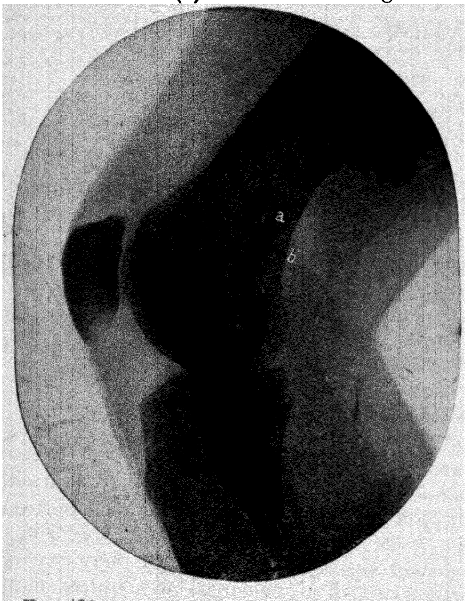

FIG. 428.—Supracondylar osteotomy of femur.
a. Position of skin incision.
b. Line of division of bone.

Different forms of operation. — Several different methods of operation are practised for the rectification of the above forms of malformation of the femur. The three most important ones are :—

(*a*) Transverse division of the femur just proximal to the epicondyles (Macewen's supracondylar operation), through an incision on the medial side.

(*b*) Transverse division of the femur a short distance proximal to the epicondyles, through an incision on the lateral side.

Supracondylar osteotomy of the femur (Macewen's operation).—*Position.*—The patient is placed in the dorsal position, with the knee somewhat flexed, and the lower extremity rotated laterally so as to lie upon its lateral side. A moderate-sized sandbag is placed beneath the knee of the affected side, so as to support it.

It is advisable in this operation to remove all mattresses and pillows from between the patient and the operating table.

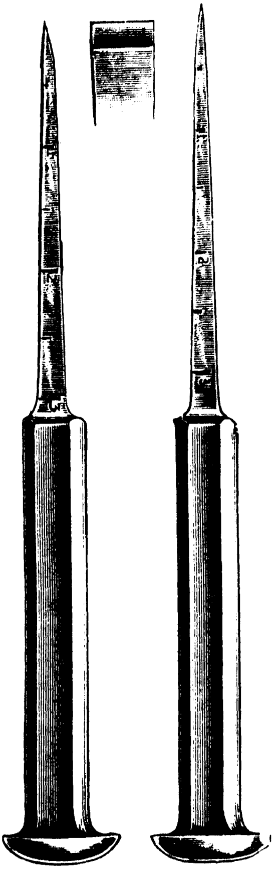

FIG. 429.—Macewen's osteotomes.

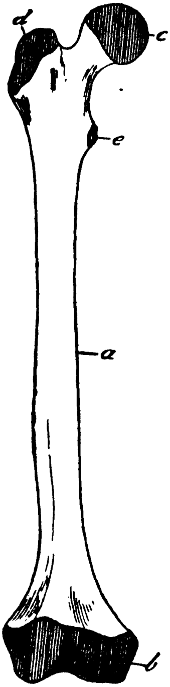

FIG. 430.—Femur, showing parts derived from primary and secondary centres.

a. Shaft.
b. Distal epiphysis.
c. Head.
d. Large trochanter.
e. Small trochanter.

The surgeon stands on the opposite side of the patient to the affected limb, and his assistant opposite to him.

Operation.—A point is taken half an inch proximal and anterior to the adductor tubercle, this level being some little distance proximal to that of the epiphyseal line of the femur. A long-bladed scalpel is pushed inwards to the bone, the incision being parallel to the long axis of the limb. All the soft tissues, including the periosteum, are divided down to the bone for about three-quarters of an inch or more if requisite. The osteotome is now passed downwards to the bottom of the wound along the blade of the scalpel, which serves as a director. The scalpel is then withdrawn, and the osteotome is turned until its blade is at right angles to the shaft of the femur. A series of short sharp strokes is given with the mallet, so as to drive the cutting part of the osteotome through the femur. The osteotome should be so manipulated that the postero-medial margin of the femur is first divided, and the section then continued forwards and laterally in such a manner that the posterior fourth of the femur is left undivided. The section of the femur should be made at right angles to its shaft; if this is not done the cut may extend in young people into the epiphyseal cartilage, a complication which ought to be avoided.

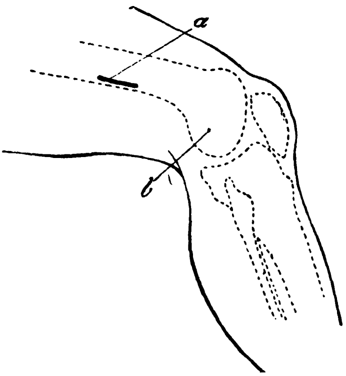

FIG. 431. — Osteotomy of femur. Transverse division through a lateral incision.

a. Position of incision.
b. Prominence of lateral epicondyle.

After each blow with the mallet the osteotome should be moved to and fro, so as to prevent its becoming impacted in the bone, but any upward and downward movement (with reference to the long axis of the limb) must be avoided. The latter part of the section of the bone may be facilitated by using a smaller instrument, but this is not usually requisite. The movements of the osteotome can be best controlled by grasping it in such a way that the ulnar aspect of the hand rests on the patient's thigh.

When the section with the osteotome has extended to the lateral part of the bone the instrument is removed. If it is the left limb which is being operated upon, the thigh is then grasped with the right hand a short distance above the line of section, the leg with the left hand, and by forcible flexion the remaining part of the bone is fractured.

The limb is brought into a straight position; one or two points of suture are used to close the skin incision, and aseptic dressings applied.

The limb is fixed in position by the application of a Thomas splint with Sinclair extension, which may, if preferred, be changed for plaster when the stitches are removed.

After-treatment.—The plaster case should be kept on for about ten weeks from the time of operation. It is then removed, and if union is found to be firm the patient is allowed to get about on crutches, with a calliper extension splint applied to the injured limb.

Transverse division of the femur proximal to the epicondyles through a lateral incision.—In this operation the skin incision is usually made at a somewhat more proximal level than in the previous operation.

Position.—The patient is placed in the dorsal position; the affected limb is slightly flexed and rotated medially, a sandbag being placed at its medial aspect to support it.

The surgeon stands at the outer side of the affected limb, and the assistant opposite him.

Operation.—An incision is made about ¾ inch in length, 3 inches proximal to the lateral epicondyle of the femur (Fig. 431). This incision divides the skin, fasciæ, vastus lateralis muscle, and periosteum. Either a saw or an osteotome may be used for the division of the bone.

In the former case an osteotomy saw, of the shape shown in Fig. 432, is passed along the knife down to the bone; the knife is withdrawn, and the bone divided for two-thirds of its extent by a series of short to-and-fro movements. The saw is now withdrawn, and the remaining part of the bone fractured as in Macewen's operation.

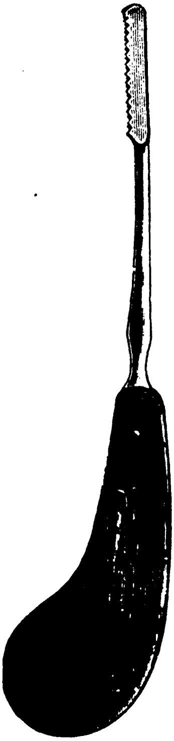

FIG. 432.—Osteotomy saw.

If an osteotome is used, the procedure is similar to that described in the previous operation, with the exception that the section is commenced from the lateral side.

When the section of the bone has been completed the wound in the soft tissues is washed out so as to remove all bone dust and other foreign material, and the skin incision closed with sutures. Splints are afterwards applied, as in the previous case.

Osteotomy of the proximal extremity of the femur.—Division of the proximal portion of the femur may be affected either through the neck of the bone or through the shaft below the trochanters. The latter operation is the more easy to perform, and gives better results. Moreover, in many cases which require this procedure the neck of the bone has been partially or completely destroyed as a result of disease.

Indications.—(*a*) Ankylosis of hip-joint, with the limb fixed in a bad position. This may be due to previous tuberculous disease of the hip-joint; to suppurative arthritis, such as occurs in pyæmia; or to ankylosis after gonorrhœal arthritis or other form of infective arthritis.

(*b*) Some cases of coxa vara.

Position.—The patient lies somewhat on the sound side, with the lateral aspect of the affected hip well exposed. The operator stands on the affected side of the patient, and the assistant directly opposite to him.

Operation.—A point is selected on the lateral side of the limb a short distance below and anterior to the large trochanter of the femur (Fig. 433). A long-bladed scalpel is pushed inwards down to the bone at this point, with its blade parallel to the long axis of the limb, and the skin, fasciæ, muscle, and periosteum are divided. The incision should be about three-quarters of an inch in length, or more if requisite. The osteotomy saw is pushed along the blade of the knife down to the bone, the latter instrument being now withdrawn. With the saw the femur is divided for the anterior three-fourths of its thickness. The saw is then withdrawn and the thigh is forcibly straightened, by which means the remaining part of the bone is fractured. The incision in the soft tissues is closed with sutures, a dressing is applied, and the limb fixed in the rectified position by means of a Thomas splint with Sinclair extension.

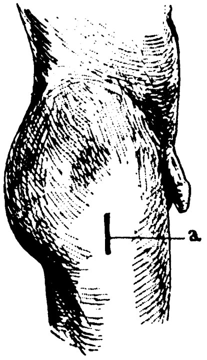

Fig. 433.—Osteotomy of femur. Sub-trochanteric operation.

a. Position of skin incision.

After-treatment.—The limb should be kept in the new position until firm union has been obtained, usually for about ten weeks, after which a walking calliper splint must be worn for another two months.

It is not advisable to attempt to create a false joint at the line of section, since very poor results have usually followed such attempts.

Some surgeons have advocated division of the neck of the femur within the capsule. This is effected through an incision above the large trochanter. In my opinion, however, this operation does not give such good results as the one which has been above described.

Osteotomy of the tibia.—This operation may consist in either simple transverse section of the tibia, or section combined with removal of a wedge-shaped portion.

Indications.—(*a*) Malformed curved tibiæ, due to rickets, syphilis, osteomalacia, or injury.

(*b*) Certain cases of ankylosis of the knee-joint in which the limb is in a bad position and excision of the joint is not considered advisable.

Position.—The patient is placed in the dorsal position, with the affected limb lying upon its lateral side, a sandbag being placed beneath it. The surgeon stands on the outer side of the limb, and the assistant opposite him.

Operation.—(*a*) *Simple transverse section of the tibia.*—A vertical incision 1 inch in length is made over the most prominent part of the deformed portion of the bone. In making this incision it is advisable to pull the skin well inwards with the left hand, so that, after the section of the bone has been made, the superficial opening may be a short distance from the line of fracture. The soft parts—skin, fasciæ, and periosteum—are divided down to the bone. The periosteum is detached from the surface of the bone on each side of the incision and the osteotome is then introduced, its cutting part turned at right angles to the long axis of the tibia, and that bone divided with the aid of the mallet, as in osteotomy of the femur. An osteotomy saw may be used in place of the osteotome if preferred.

The tibia having been almost completely divided in this manner, the limb is grasped above and below the plane of section and forcibly straightened. In doing this the fibula is fractured at the same time that the undivided portion of the tibia is broken across.

The wound is sponged dry, closed with a few points of suture, and dressings applied. The limb is fixed in the rectified position, by the application of back and side splints.

After-treatment.—Careful attention should be paid to the position of the limb, so as to avoid any displacement. After from five to seven days the splints are taken off, the stitches removed, and the limb put in a plaster or silicate case.

(*b*) *Transverse osteotomy, with removal of a wedge-shaped portion of bone.*—The first stage of this operation is similar to the above, with the exception that the incision is made a little longer and the periosteum is detached from the tibia for a short distance, usually 1 or 1½ inches. The soft parts, including the periosteum, are held aside with retractors, and a wedge-shaped portion of the tibia, the base of the wedge being anterior, removed with a chisel (Fig. 434). Care must be taken completely to divide the bone posteriorly, and if there is any difficulty in getting the limb straight the periosteum on the posterior part of the tibia should be divided also. The wedge-shaped piece of bone having been removed, the limb is forcibly straightened and put up in splints, as in the preceding case.

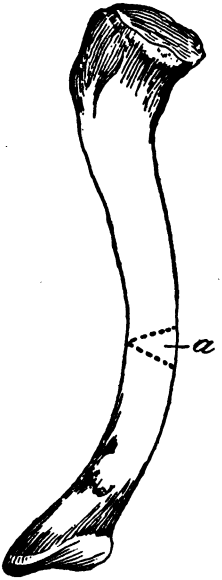

FIG. 434.—Osteotomy of tibia. Removal of wedge-shaped portion.

a. Position of bone to be removed.

In certain cases of bony ankylosis of the knee-joint, with the limb in a faulty position, it may be necessary, in order to rectify the deformity, either to divide or to divide and remove a wedge-shaped portion from the proximal extremity of the tibia.

This operation is similar to the preceding one, with the exception that the skin incision is made over the proximal fourth of the tibia.

Operations for fracture of bones. —*Indications.*—(*a*) Cases of ununited fracture, in which the application of splints has failed to secure body union (most commonly seen in humerus but also met with in the femur, tibia, radius and ulna, and those fractures of the patella and olecranon which have not been operated upon shortly after the injury).

(*b*) Some cases of recent fractures in which the fragments cannot be brought into or maintained in direct apposition, either (1) on account of strong muscular contraction—as in the olecranon; (2) some muscular aponeurotic or other structure intervenes between the broken ends—as in the patella, femur, etc.

(*c*) Some cases of compound fracture, especially those extending into a neighbouring joint, associated with much displacement of fragments.

Special instruments.—Periosteal elevators, chisel, mallet, osteotomy saw, bradawl, bone drill, silver wire (if it is necessary to fix the fragments together), bone plates, screws, screw driver and suitable splints.

Fractures of the femur.—*Preliminary preparation.*—In those cases of ununited fracture of the femur, or of recent fracture in which operation is considered advisable, in which there is considerable shortening owing to malposition of the fragments of bone, it is advisable to keep the patient in bed for a few days previous to the operation, and to apply extension to the affected limb. By this means the deformity will be lessened, the muscles somewhat lengthened, and it will be possible to fashion a suitable splint for application after the performance of the operation.

Position.—The patient is placed in the dorsal position, with the thigh of the affected limb resting upon a sandbag. The surgeon stands upon the affected side of the patient, and the assistant upon the sound side.

Operation.—The position of the fracture is first defined. A vertical incision 4 or 5 inches in length is made on the lateral side of the limb, the centre of the incision being opposite the seat of fracture. The soft tissues of the thigh—skin, fasciæ, muscle, and periosteum—are divided down to the bone for the entire length of the incision. Next, the free extremities of the fractured ends of the bone are laid bare by turning aside the soft tissues surrounding them, and at the same time the periosteum is detached from the femur above and below the fracture for a distance of about ½ inch, or more if necessary. The ends of the bone having been freed in this manner; in the case of old fractures, the limb is bent until one of them projects into the wound,

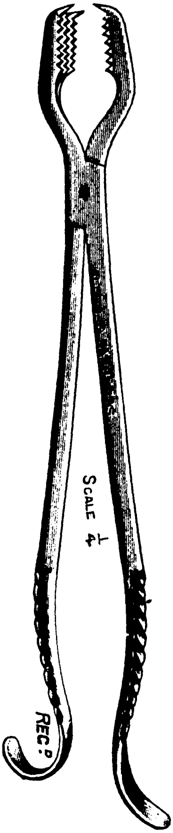

FIG. 435.—Forceps for grasping femur or other long bone during application of bone plates, etc.

the fibrous tissues between the ends of the bone being cut through in order to allow this to be easily effected. The soft

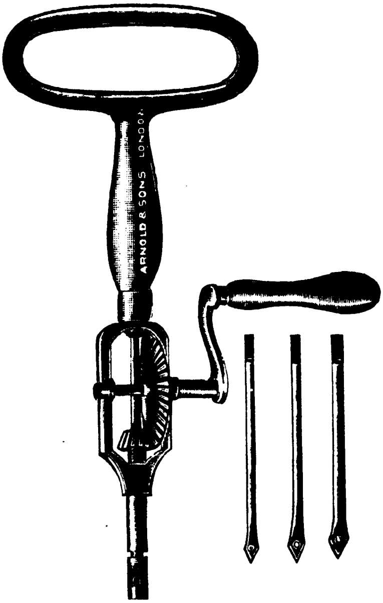

FIG. 436.—Drill for making holes in bones before inserting screws for fixation of plates.

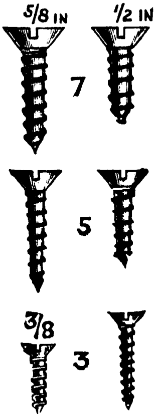

FIG. 437.—Screws for fixation of bone plates,

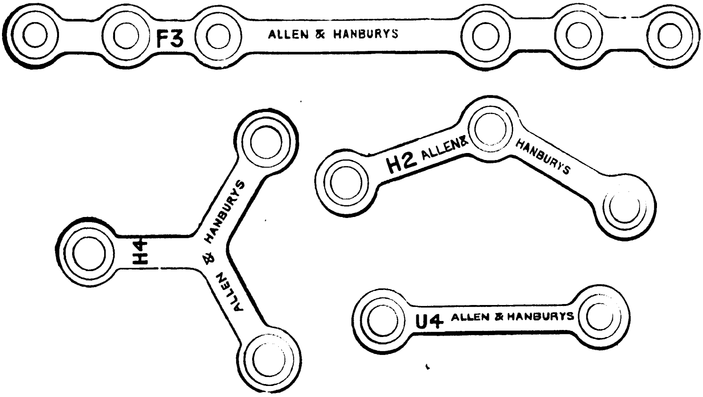

FIG. 438.—Bone Plates.—LANE.

parts are protected with flat retractors, and then with chisel and mallet a portion of the end of the bone about a ¼ inch in thickness, or whatever thickness may be necessary, is removed. The other extremity is now brought into the wound

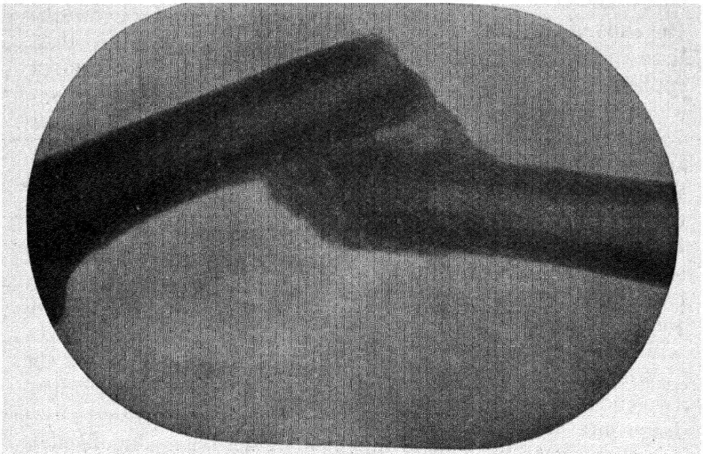

FIG. 439.—Fracture of femur in bad position.

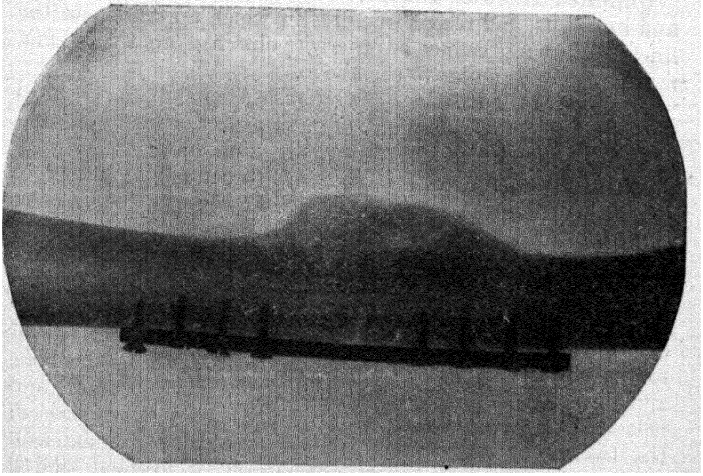

FIG. 440.—Fracture of femur after rectification and application of bone plates.

and treated in a similar manner. In making the section of the bone, care must be taken so to fashion the two free extremities that they may fit one another when brought together. In order to do this satisfactorily it is better to make one end somewhat convex and the other somewhat grooved or concave. The ends of the bone, when properly prepared, are brought into apposition, and the external wound closed. Splints are then applied, so as to fix the limb immovably in the position in which it has been placed.

When the two ends of the bone cannot be brought into exact apposition and kept there, they should be fixed together by sutures of strong silver wire, metal screws, or a plate moulded to the bones and perforated for screws. In my opinion, however, these methods of fixation of the bone are only required in a small percentage of cases, since, if care be taken to make a free exposure of the fractured ends, to fashion the two extremities so that they fit together, and to apply suitable splints, few failures will be met with.

When, however, the line of fracture is very oblique, or the two ends cannot be made to remain in good apposition, the two fragments should be joined together by one or two stout silver wire sutures or by a plate moulded to the bones and fixed in position by screws.

Ununited fractures of the tibia and fibula, radius and ulna, and humerus, and recent fractures in which apposition of the fractured surfaces cannot be otherwise obtained, are treated in a manner exactly similar to the above.

Fracture of the patella.—*Operation.*—A semilunar or vertical incision is made over the inner or outer aspect of the limb, commencing 1 inch above the distal border of the proximal fragment, and terminating 1 inch below the proximal border of the distal fragment. The choice as to whether the incision should be placed medially or laterally depends on the extent of the concomitant solution of continuity in the aponeurosis of the quadriceps extensor, the side being selected where the tear in the aponeurosis is greatest. This can usually be readily determined by palpation. The soft parts are divided down to the anterior surface of the aponeurosis covering the bone and dissected outwards or inwards for a short distance, and held aside by retractors. In this way the anterior surface of the two fragments of the patella covered by the extensor aponeurosis or torn extensor aponeurosis, is exposed, and if the fracture is not a recent one, the intervening fibrous tissue which holds them together. All bleeding is now arrested, and the blood clot or fibrous tissue which lies between the two fragments is removed. When the knee-joint has been thus laid open, all fibrin and blood clot is removed from its interior and also from the fractured surfaces of bone. Next, in old-standing cases a thin layer of bone is taken away from the fractured surfaces with the chisel and mallet. This proceeding is only necessary in patients in whom the fracture has occurred some time previously. The fragments are now pierced with a bradawl or bone drill (Fig. 436) in the manner shown in Fig. 442. It is best to pierce each fragment about ½ inch from the middle line on each side. A suture of strong silver wire, about $\frac{1}{12}$ inch in thickness, is passed through the perforation in each half of the bone, and by tightening and twisting this the prepared surfaces of the two fragments are fixed in apposition, all blood and débris having been previously sponged away. The ends of the suture are cut short and hammered into the upper margin of the bone. In the majority of instances it is advisable to have two sutures, each being inserted ½ inch towards the

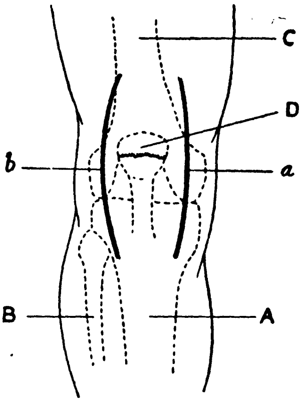

FIG. 441.—Operation for fracture of patella.

a. Position of internal incision.
b. Position of external incision.

A. Tibia.
B. Fibula.
C. Femur.
D. Patella.

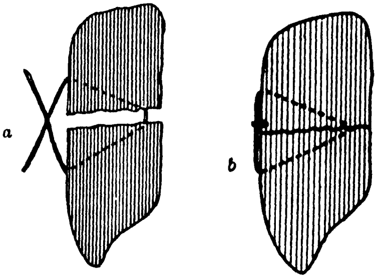

FIG. 442.—Section of patella.

a. Showing method of inserting wire sutures.
b. Showing wire sutures inserted and fixed.

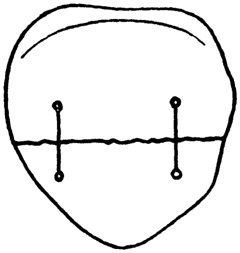

FIG. 443.—Position of sutures on anterior aspect of patella.

corresponding side of the middle line. The silver wire may be replaced by strong salmon-gut. I have used salmon-gut for cases of recent fracture of the patella with good results. A disadvantage of silver wire is, that often some months later the patient returns on account of the "knot" of the wire projecting underneath the skin. An operation is then necessary for its removal. This is not necessary when salmon-gut is used.

The aponeurosis of the quadriceps extensor tendon is generally torn on each side of the fracture in the patella.

In these cases the margins of the tear in the aponeurosis on each side should be approximated and fixed in close apposition by the insertion of sutures of No. 2 chromicised cat-gut or silk. Also a few points of suture should be inserted between the approximated margins of the torn aponeurosis on the superficial aspect of the patella. The external wound is closed by the insertion of silkworm-gut sutures, and the limb is fixed in the not quite fully extended position by the application of splints. Passive movements of the knee-joint should be commenced at the end of eight to ten days from the time of operation. Some surgeons advise that when union is complete the wire suture should be removed through an incision made over it. This is not always necessary.

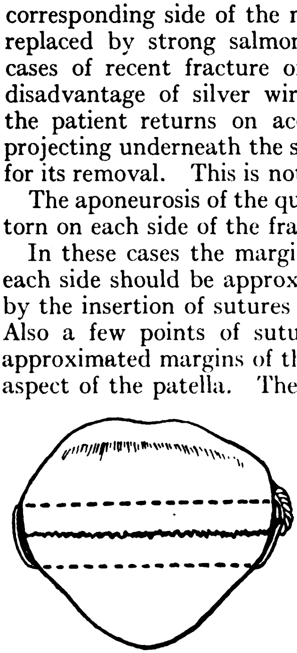

FIG. 444.—Fracture of patella. Method of inserting wire from side to side.

Fracture of the olecranon.—In fracture of the olecranon, an operation similar to the one described for fracture of the patella may be made use of.

Operation.—A vertical incision is made in the long axis of the limb, over the posterior aspect of the elbow. The fragments are defined, all blood clot and fibrin removed from the interior of the joint, the fractured surfaces separated from all fibrous tissue and synovial membrane, and freshened, if necessary, in old cases by the removal of a plate of bone with the chisel, and then fixed in apposition by the insertion of wire or strong salmon-gut sutures. The limb is put up on an anterior splint, and maintained in position of almost complete extension.

In many cases of widely separated ununited fractures of the patella and olecranon, difficulty is experienced in bringing the surfaces of the fractured portions of the bones together. When this happens the fibres of the rectus femoris muscle might be divided in the former case, and those of the triceps humeri in the latter, just above their insertion.

Excision of bones.—Excision of a bone may be either partial or complete. In the former case only a part of the bone, either of the shaft or an extremity, is taken away; in the latter, the entire bone, including its articular surfaces, is removed. Sometimes a bone is only partially detached and turned aside, and afterwards replaced and fixed in its original position. This is called " temporary " or osteoplastic resection, and may be performed, for example, in the case of the upper jaw, to allow of the removal of a naso-pharyngeal polypus. It is also employed in connection with the cranial vault, in order to obtain a free exposure of portions of the brain or membranes.

Special instruments.—Resection knife, bone forceps, lion forceps, periosteal elevator, sequestrum forceps, and saw.

Indications.—(*a*) New growths of bone, especially myeloid sarcomata.

(*b*) Localised inflammatory affections associated with the formation of sequestra or abscesses.

(*c*) Some forms of malformation, either congenital or acquired, such as inveterate club-foot.

(*d*) As a temporary measure in some forms of intracranial growth, and in the removal of naso-pharyngeal polypi.

Temporary excision of a portion of the bony wall of the cranium is described on p. 487–8.

Excision of the maxilla.—This may be (1) complete, (2) partial, or (3) temporary.

Preliminary laryngotomy and plugging of the lower part of pharynx is often advisable in the *Complete* operation, since it allows the surgeon to carry on the operation without any disturbance from blood passing into the air passages, and the anæsthetist does not interfere with his movements; but in the partial or temporary operations it is not generally necessary. Anæsthesia by the endo-tracheal method, the tubes being introduced via the nose and naso-pharynx and in the hands of a skilled anæsthetist can be adopted with advantage.

1. *Complete excision of the maxilla.*—This operation is performed for malignant growths of the maxilla, sarcomatous or carcinomatous, which have not extended widely beyond this structure into the adjacent tissues.

Special instruments.—In addition to the ordinary instruments for the excision of a bone, a gag and a pair of upper incisor dental forceps are required. A keyhole saw and a Hey's or other form of small saw are also required.

Position.—The patient is placed in the dorsal position, with the head well supported by a pillow, and near the right margin of the operating table. The surgeon stands on the right side of the patient (both for right and left upper jaws), and the assistant stands on the left, directly opposite to him. In some cases, placing the patient in a semi-sitting posture may be an advantage.

Operation.—The operation for the removal of the upper jaw may conveniently be divided into the following stages :—

(*a*) *External incision, and dissection back of cheek-flap.*—An incision is made, commencing below and a little medial to the medial canthus of the eye of the affected side, extending downwards along the lateral aspect of the nose as far as the ala, then horizontally medially to the middle line opposite the septum, and finally vertically downwards through the upper lip into the mouth (Fig. 445). From the same starting-point a second incision is carried outwards parallel with the inferior margin of the orbit, as far as the prominence of the zygomatic bone. Both parts of the incision divide skin, fasciæ, and muscle, and a flap is dissected back including all the soft tissues of the cheek except the periosteum. By this means the external surface of the maxilla is laid bare. Next, the periosteum along the inferior margin of the orbit is divided, and the orbital contents lifted upwards for a short distance, so as to define the position of the anterior portion of the pterygo-maxillary fissure and the groove in the lachrymal bone. The cavity of the nose is also opened by detaching the nasal cartilages from their lateral connection with the bone. As the operation proceeds, all blood vessels which are cut across are seized with pressure forceps and ligatured. At the medial canthus ascending branches of the external maxillary (facial) artery will require ligature.

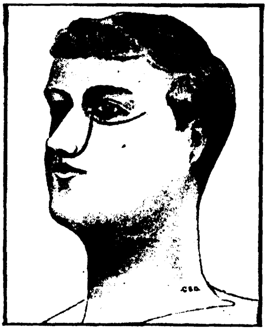
FIG. 445.—Excision of upper jaw.

Position of external incision.

(*b*) *Division of bony connections, and removal of incisor tooth.*—With a Hey's or other saw or an appropriately shaped pair of strong cutting bone forceps the nasal process of the maxilla is divided by a cut which extends from the margin of the bony nasal aperture to the groove in the lachrymal bone. A second cut is made through the bridge of bone which separates the anterior extremity of the pterygo-maxillary fissure from the external surface of the zygomatic bone. Care should be taken in so doing that the zygomatic prominence is left behind, in order to prevent too great a falling-in of the cheek afterwards. In dividing the nasal process of the maxilla the attachments of the medial orbital ligament must be carefully preserved, otherwise the suspensory ligament of the eyeball will be rendered more or less useless, and the eyeball will afterwards prolapse and come out upon the cheek.

With the dental forceps the central incisor tooth on the affected side is removed, and then with the scalpel the mucous membrane and periosteum along the floor of the nose on the affected side, and on the under surface of the hard palate, are divided, together with a small portion of the soft palate at its junction with the hard.

With a keyhole saw the alveolar and palatal processes of the maxillary and palate bones are divided, the saw being passed into the nose for this purpose. In performing this section of bone, care must be taken not to allow the saw to travel too far backwards, otherwise the base of the skull or the naso-pharynx may be injured.

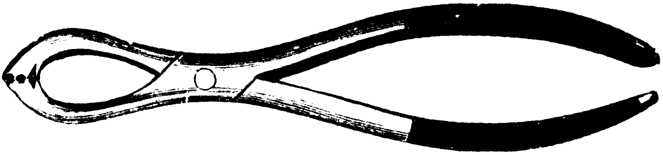

FIG. 446.—Excision of maxilla. Lion forceps.

(*c*) *Division of soft palate and removal of jaw.*—With the scalpel the soft palate of the affected side is completely divided in a transverse direction. Next, the lion forceps (Fig. 446) are taken, one blade placed on the margin of the orbit, the other in the mouth, and by a forcible wrenching and screwing movement the entire upper jaw is removed. This part of the operation (incision of the soft palate and removal of the maxilla) should be effected as quickly as possible, on account of the severe hæmorrhage which may occur.

The jaw having been removed, the place it occupied is at once packed with sponges, so as temporarily to arrest bleeding. All blood is sponged out of the mouth and pharynx, and any bleeding vessels ligatured. In some cases it may be necessary to make use of a Paquelin's cautery, to arrest hæmorrhage from vessels in the bone. When all hæmorrhage has been arrested the wound is packed with tampons of gauze, the ends of which are left projecting toward the mouth, and the skin incision closed by the insertion of a series of interrupted sutures of horse-hair or fine salmon-gut. The first of these sutures to be inserted should be the one at the medial canthus, the second the one at the margin of the lip, the third that by the septum of the nose. All the sutures having been tied and cut short, the line of incision is covered with a collodion dressing.

After-treatment.—At the end of twenty-four hours the tampons of gauze are removed, the wound syringed out through the mouth and packed as before. This process of dressing is repeated daily. The sutures are taken out at the end of five days or a week.

If the prominence of the zygomatic bone has been removed it will usually be found necessary to fit up the patient with an obturator or artificial upper jaw, so as to obliterate the flattening and consequent deformity of the cheek. If, however, the prominence of the zygomatic bone is left, no artificial aid of this kind will usually be required.

2. *Partial excision of the maxilla.*—Some surgeons have advocated leaving the orbital portion of the maxilla in cases of excision of the upper jaw. When, however, excision is undertaken for malignant growths of this bone, whether sarcomata or carcinomata, it is not advisable to leave this part of the bone behind, owing to the great liability to recurrence of the disease in the part left.

Partial excision of the maxilla may, however, be practised with advantage under the following circumstances :—

(*a*) In removal of dentigerous cysts.
(*b*) In removal of a fibrous or myeloid epulis.
(*c*) For drainage of the antrum of the maxilla.
(*d*) For removal of the spheno-palatine ganglion.

The precautions to be observed in removal of portions of the upper jaw are described in the different chapters which deal with the individual operations.

In removing a part of the jaw on account of a growth, the teeth in the immediate neighbourhood should first be extracted, and then the entire portion of the bone involved in the growth, together with its periosteum, should be completely removed.

3. *Temporary excision of the maxilla.*—Temporary or osteoplastic excision of the upper jaw has been practised in a few cases for removal of naso-pharyngeal tumours.

The details of the operation have been described in connection with the removal of naso-pharyngeal polypi (p. 376).

Excision of the lower jaw.—

Indications.—(*a*) Sarcoma of the mandible.

(*b*) Carcinoma of the floor of the mouth extending into the mandible.

(*c*) Cystic epithelioma (epithelial odontome) of the mandible.

(*d*) In some cases of extensive necrosis.

Special instruments.—As for removal of the upper jaw.

Position.—The patient is placed in the dorsal position, with the head slightly raised by a sandbag and turned towards the sound side. The operator stands on the affected side of the patient, and the assistant on the opposite side.

Operation.—An incision is made through the lower lip, commencing at the junction of the red portion with the skin, and extending downwards to the symphysis menti, then along the horizontal ramus to the angle, and finally upwards as far as the level of the lobule of the ear (Fig. 447). This incision extends down to the bone, except in the neighbourhood of the external maxillary (facial) artery at the anterior border of the masseter muscle. The external maxillary (facial) artery is isolated, tied in two places, and cut between. Then all the soft tissues of the cheek, except the periosteum, are dissected up from the bone. The mandible is now sawn through ½ inch external to the symphysis menti, an incisor tooth being first extracted, if requisite. The mucous membrane of the floor of the mouth, and the various muscles which are attached to the internal aspect of the mandible are separated as far back as the angle. The horizontal ramus of the jaw is then grasped by the left hand of the operator, and the bone depressed so as to bring forwards and render evident the coronoid process and temporal muscle. The internal pterygoid is completely detached from the angle and ascending ramus, and the spheno-mandibular ligament cut through where it is fixed to the internal margin of the inferior alveolar (inferior dental) foramen. The inferior alveolar (inferior dental) artery is picked up with pressure forceps

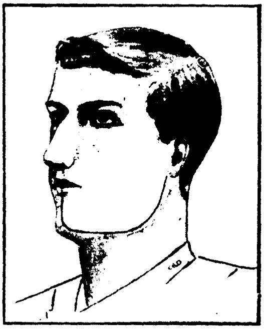

Fig. 447.—Excision of lower jaw.

Position of skin incision.

just before it enters the foramen, and cut across, together with the corresponding nerve. The insertion of the temporal muscle into the coronoid process is now detached, and the pterygo-mandibular ligament divided. The ramus of the jaw is then further depressed so as to render prominent the condyle. The capsular ligament of the temporo-mandibular articulation is opened, and then divided all the way round, together with the external pterygoid muscle, which is inserted into the neck of the condyle at its medial aspect. When this has been done the jaw can be completely removed. Care must be taken throughout the operation not to twist the lower jaw upon its axis, otherwise the internal maxillary artery, which lies in close relation with the neck of the bone, will run great risk of being injured. All through the operation the cutting edge of the knife should be kept close to the bone.

After the removal of the bone all bleeding vessels are tied, and the external wound is closed by the insertion of a number of sutures, and packed from the interior of the mouth with tampons of gauze. It is in most cases advisable to place a drainage tube in the lower and posterior angle of the wound.

Partial excision of the lower jaw.—

Indications.—(*a*) Epulis.

(*b*) Dentigerous cyst (follicular odontome).

(*c*) Cases of inveterate ankylosis of the tempora-mandibular articulation, in which it is wished to make a false joint.

(*d*) Necrosis.

(*e*) Myeloid sarcoma.

(*f*) As a part of the operation in removal of the tongue for carcinoma, when the disease has extended to the bone.

In the majority of cases of removal of a portion of the mandible, especially when it is done for epulis or dentigerous cyst, the operation can be carried out through the mouth. In those cases, however, in which a considerable portion of the bone requires removal, or in which there is any difficulty in performing the operation through the mouth, an incision through the cheek, along the affected portion of the bone, should be made.

Position.—As for the preceding operation.

Operation.—The affected portion of the bone, together with the adjacent part of the floor of the mouth and internal surface of the cheek, are thoroughly exposed, either by opening the mouth with the gag and pulling aside the soft parts with retractors, or by making an incision through the tissues of the cheek overlying the portion of bone involved. Any teeth which may be present in the affected part of the jaw are removed. The mucous membrane and the periosteum are divided with a scalpel a short distance from the margin of the growth, and then with a chisel and mallet the affected portion of the bone is removed. If possible, a bridge of bone should be left along the inferior margin of the jaw, but this must not be done at the risk of leaving any diseased tissue behind.

After the arrest of hæmorrhage the wound is packed with tampons of gauze.

Removal of a wedge-shaped portion from the horizontal ramus of the lower jaw.—This operation has been carried out in cases of closure of the lower jaw dependent upon extensive contraction following burns or cancrum oris.

The wedge-shaped portion of bone is removed from the horizontal ramus immediately in front of the attachment of the masseter muscle, the apex of the wedge being at the alveolar margin and the base at the lower border. Fig. 448 shows the portion of bone which is removed in this operation.

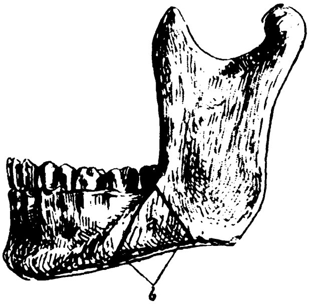

Fig. 448.—Removal of a wedge-shaped piece from lower jaw.

a. Part to be removed.
b. Lines of saw cuts.

Operation. — An incision 2 inches in length is made parallel with the horizontal portion of the lower jaw, commencing at the anterior border of the masseter and extending forwards towards the symphysis. The soft parts are divided, the external maxillary (facial) artery being pulled forwards or backwards, and the external surface of the jaw exposed. The periosteum is now cut through, and the wedge-shaped piece of bone separated with a narrow-bladed saw. When the bone has been sawn through, the attachments of the mylo-hyoid muscle to its deep surface are cut through, together with the mucous membrane in the floor of the mouth. The separated piece of bone can then be completely removed.

All bleeding is arrested, the interior of the wound packed with tampons of gauze, the ends of which project towards the mouth, and the skin incision closed by the insertion of a series of interrupted sutures.

Good results are said to have followed this operation. Mastication can only be performed on one side.

Excision of the clavicle.—

Indications.—(*a*) Periosteal sarcoma of the clavicle.

(*b*) Acute necrosis.

(*c*) Some cases of backward dislocation of the sternal extremity of the clavicle may require excision of this portion of the bone.

Excision of the entire clavicle.—This is only necessary in cases of malignant growth.

Position.—The patient is placed in the dorsal position, with the shoulder on the affected side slightly raised by a pillow. The operator stands on the affected side, and the assistant opposite to him.

Operation.—An incision is made over the entire length of the bone, commencing medially over the sterno-clavicular articulation, and following the outline of the clavicle to the acromion. This incision divides everything down to the bone except the periosteum, namely, skin, fasciæ, platysma, and supra-clavicular nerves. The soft tissues are dissected upwards and downwards, the periosteum being left behind except in cases of sarcoma, when it is removed along with the bone. When the bone has been sufficiently bared the shaft is sawn through in a convenient situation, usually near the middle, with a Hey's saw, care being taken not to injure the important blood vessels and nerves which lie directly behind it. The sternal extremity is lifted up, the muscles and ligaments attached to its posterior surface divided, and the capsular ligament of the sterno-clavicular joint cut through, after which it can be removed. The outer half of the clavicle is treated in a similar manner. The conoid and trapezoid ligaments are divided close to the coracoid process, the acromio-clavicular joint is opened and its ligaments cut through, and the bone removed.

Any bleeding vessels are ligatured, and the external wound closed by a series of interrupted sutures.

Removal of the diaphysis of the clavicle in cases of acute necrosis.—An incision is made over the middle of the bone parallel with its long axis, and all the soft tissues, including the periosteum, are incised down to the bone. By this means the necrosed portion is laid bare. With a pair of bone forceps the diaphysis is divided transversely, and extracted in two halves with the aid of sequestrum forceps.

The space left by the removal of the diaphysis is thoroughly irrigated, then packed with strips of gauze, the extremities of which project from the external wound.

Excision of the sternal extremity of the clavicle.—An incision, usually about 2 inches in length, is made, commencing over the manubrium sterni and extending outwards over the sternal extremity of the clavicle. The soft tissues are divided until the anterior surface of the bone is exposed. The pectoralis major and the clavicular head of the sterno-mastoid are detached, and with a Hey's or other form of saw the shaft of the bone is divided at the outer extremity of the incision. The medial portion of the bone is seized with lion forceps and pulled forwards, and the muscles and ligaments attached to its posterior and inferior aspects cut through. These include the costo-clavicular ligament, the costo-coracoid membrane, and portions of the subclavius and sterno-hyoid muscles. Finally, the capsular ligament of the sterno-clavicular articulation is cut through with the scalpel, and the separated portion of the bone removed. All bleeding is arrested, and the external wound closed.

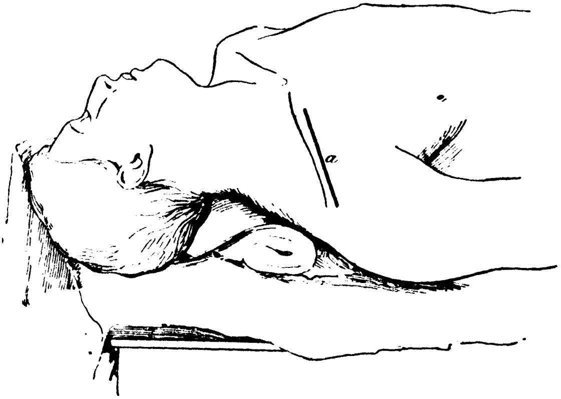

FIG. 449.—Excision of clavicle.
a. Position of external incision.

Excision of the scapula.—*Indication.*—Primary sarcoma of the scapula.

Position.—The patient is placed lying upon the sound side, turned a little more towards the ventral than the dorsal position, or in the semi-prone position so as to fully expose the affected shoulder. The surgeon stands directly behind the patient, and the assistant on the opposite side.

Operation.—An incision is made, commencing over the acromion of the scapula, and extending along the spine of the bone as far as the vertebral border. This incision divides all the soft tissues down to the bone.

A second incision is then made along the vertebral border of the scapula, commencing at the medial angle and extending downwards to the inferior angle.

Two flaps are then dissected up; they should, if practicable, include all the soft tissues except the periosteum, but care must be taken to avoid leaving any diseased tissue behind, and as the operation is being carried out for malignant disease the tissues should be divided some distance from the margins of the growth. These flaps are dissected outwards until the superior and lateral margins of the bone are laid bare. Next, the muscles along the superior and vertebral borders are detached; that is to say, the rhomboids, levator scapulæ, and posterior belly of the omo-hyoid. This having been done, the vertebral border is lifted upwards and laterally and the serratus anterior (serratus magnus) and subscapularis muscles separated from the ventral aspect. The acromion is sawn through at its junction with the spine and drawn forwards. By this means the superior aspect of the shoulder-joint is exposed. The capsule of this joint is now divided, together with any of the adjacent muscles or tendons which still remain. The scapula is next pulled downwards and laterally, and the muscles attached to the axillary border and inferior angle cut through (teres major and minor, and long head of triceps). The scapula is now free and can be removed.

It is advisable, if possible, to leave behind the acromion together with the attachments of the deltoid and trapezius; but if the disease extends into this part of the bone, these muscles must be cut through and the bone removed at the acromio-clavicular joint. When the growth for which the operation is undertaken is limited to the lower portion of the scapula, it is often possible to preserve the glenoid cavity by sawing through the bone a little above it.

All bleeding is arrested and the external wound closed in the usual manner.

Partial Excision of the scapula.—This procedure may be requisite in cases of necrosis of a part of the bone, or for exostoses growing from its surface.

No special directions can be given for this operation, since each case differs according to the position of the exostosis or the sequestrum.

Excision of the radius or of the ulna.—Removal of portions of these bones may be requisite in cases of malignant growth or of localised necrosis.

The operation is usually carried out by making an incision over the most exposed portion of the affected part of the bone, turning the soft tissues aside, and removing as much of the bone as is thought necessary.

The ulna is somewhat more accessible than the radius, on account of its nearness to the surface of the forearm.

Excision of a metacarpal bone.—A metacarpal bone is usually removed through a median incision extending the entire length of its dorsal surface. The soft tissues are divided down to the bone, and separated and retracted on each side. The base is first disarticulated, the bone is lifted upwards and forwards, the muscular and ligamentous attachments on the palmar aspects separated, the head of the bone disarticulated, and the entire bone removed. In making the dorsal incision, care must be taken to avoid injury to any of the digital nerves.

Excision of a phalanx.—In the excision of a phalanx an incision is made over the lateral aspect of the bone, somewhat nearer the dorsal than the palmar surface. The soft tissues are separated as in the removal of a metacarpal bone, and disarticulation is carried out, the proximal end of the bone being separated first.

Partial excision of a metacarpal bone, or of a phalanx.—In the removal of a portion of a metacarpal bone, or of a phalanx, the external incision is made in the same line as for the removal of the entire bone. The shaft is exposed, sawn through, and the diseased portion removed.

Excision of a rib.—

Indications.—(*a*) Empyema.—1. Simple (following pleural effusion). (i) Pneumococcal ; (ii) Pyogenic.
2. Tuberculous.
3. Due to actinomycosis of the base of the lung.
4. Pyæmic.

(*b*) Caries or necrosis of a rib.

(*e*) Primary new growth (sarcoma or myeloma) of a rib.

(*d*) Injury of the chest wall, with perforation of one of the intercostal arteries.

Special instruments.—Small saw, periosteal elevator, bone forceps, probe-pointed director, Volkmann's spoon.

Position.—The position of the patient depends upon which rib or ribs have to be excised : usually the patient is turned somewhat on the sound side, so as to expose the lateral aspect of the affected side of the chest. The surgeon stands on the affected side, and the assistant directly opposite to him, or the affected side may be allowed to project slightly beyond the edge of the table ; the surgeon then sits down to operate. Care should be taken not to turn the patient so far upon the sound side as to embarrass respiration.

Operation.—The portion of a rib which requires removal is first determined. The position and extent of the cavity which requires drainage is made out, and a portion of rib 3 inches in length is demarcated, which overlies the posterior and lower part of the cavity. This having been done, an incision is made over it and parallel with it. This incision should divide skin, fasciæ, muscles, and periosteum. In many ordinary cases of empyema of the pleural cavity it will be found most convenient to excise a portion of the eighth rib in the posterior axillary line. The margins of the incision are retracted, and the periosteum separated from the external and internal aspects of the rib with a periosteal elevator. The rib itself is divided at each extremity of the incision, either with a pair of bone forceps, rib shears, or with a small saw; usually it is better to employ a large pair of cutting bone forceps or rib shears. Small or blunt bone forceps are liable to cause splintering of the bone, a condition which ought to be avoided owing to the risk of injury to the surgeon's fingers when examining the interior of the empyema cavity. If proper bone forceps are not available a saw should be used. During division of the rib the periosteum and blood vessels of the deep aspect should be protected from injury by passing a flat retractor or metal spatula underneath the rib. When the portion of rib has been removed, and it is desired to open the pleural cavity, as for the treatment of purulent collections within the chest, the periosteum and underlying fascia and pleura are divided by making an incision with the scalpel parallel to the long axis of the rib, in the middle of the space from which the excised portion of rib has been taken out, or a probe-pointed director is pushed inwards through the floor of the space which the rib occupied, and made to pierce the periosteum, the thoracic fascia, and the

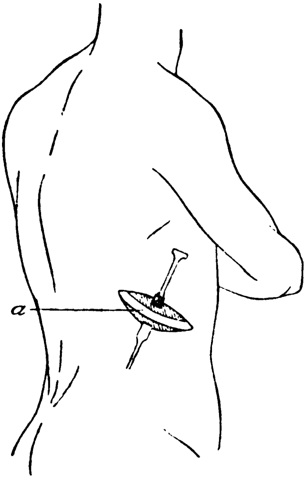

FIG. 450.—Excision of rib.
a. Rib to be excised, showing its relation to skin incision.

parietal layer of the pleura. The blades of the dressing forceps are passed into the cavity which has been opened, separated, and the opening enlarged. The interior of the chest can now be examined with the finger through this aperture, and any further measures which may be requisite carried out.

The purulent contents of an empyema of the chest should not be allowed to pour out too fast, and if the patient becomes collapsed or faint the exit should be at once arrested by plugging the aperture with the finger. As the patient's condition improves, the finger can be removed and more pus allowed to exude.

If the removal of a portion of one rib does not give sufficient access to the interior of the thorax the margins of the parietal incision are well retracted, so as to expose the adjacent rib, either the one above or the one below. This is denuded of its periosteum, and a portion removed, as in the previous case. Under these circumstances it will be necessary to ligature the intercostal vessels. This is best effected by means of a curved aneurysm needle, which carries the ligature behind the vessels. Two ligatures should be applied—one at each extremity of the wound. When this has been done, the incision may been larged by cutting transversely across between the ligatures. Care must be taken not to injure the intercostal vessels in the process of detaching the periosteum from the bone. They lie in the grooves on the superior and inferior aspects of the rib. The relative position of these structures is shown in Fig. 452. If the end of the periosteal elevator is kept within the periosteal sheath the vessels run no risk of injury.

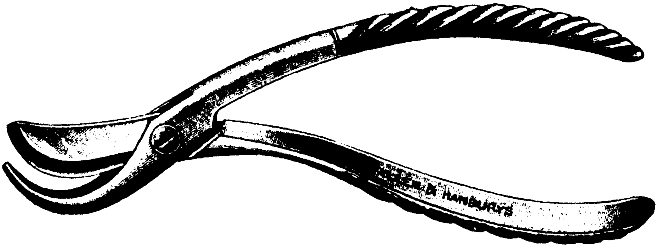

FIG. 451.—Rib forceps for removal of a portion of a rib.

When partial excision of one or more ribs is required in the treatment of an empyema, it is not necessary in most instances to remove more than about 2 inches of each. In caries of a rib the diseased portion must be entirely removed. In cases of new growth it is generally necessary to take away much more extensive pieces of bone. The incisions, both through the soft tissues and through the bone, must in such cases be carried well wide of the growth and include the periosteum.

When it is wished to drain the pleural cavity after the excision of one or more ribs the fluid collection is first allowed to escape, and then a guarded indiarubber drainage tube of suitable size is pushed through the opening into the pleura and fixed in position, and abundant absorbent dressings applied.

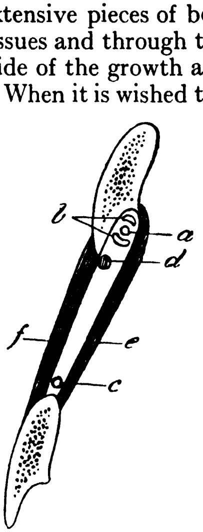

FIG. 452.—Excision of a rib. Relative position of structures in an intercostal space.

a. Intercostal artery.
b. Venæ comites.
c. Branch of intercostal artery.
d. Nerve.
e. Internal intercostal muscle.
f. External intercostal muscle.

Excision of the patella.—*Indications.*—This operation may be requisite under the following circumstances :—

(*a*) Tuberculous affections commencing in and limited to this bone.

(*b*) Necrosis of the patella.

(*c*) Primary new growth in the bone (sarcoma).

(*d*) As part of the operation of excision of the knee-joint.

Special instruments. — Periosteal elevator.

Position.—The patient is placed in the dorsal position, with the affected limb fully extended. The operator stands on the outer side of the knee, and the assistant opposite to him.

Operation.—A vertical incision 3 to 4 inches in length is made over the patella, commencing in the middle line about 1 inch above the proximal border of the patella, and extending distally almost to the tuberosity of the tibia. This incision is deepened until the superficial surface of the bone is reached, the suprapatellar bursa being cut through and turned aside. The soft tissues are then dissected from the anterior aspect of the bone, and held aside with retractors. If the periosteum is not diseased, and the operation is not being performed for a malignant growth, it should be turned aside with the other soft tissues ; but when it is the seat of tuberculous processes, or in cases of sarcoma, it should be removed along with the bone. The margins of the bone are defined, and then the fasciæ, muscular aponeuroses, fibres of vastus medialis and ligamentum patellæ are cut through. By these means the patella is separated from its connections with the soft parts, and can be removed. All hæmorrhage is arrested, the part of the knee-joint exposed in the wound sponged clean and dry, and the margins of the incision united by the insertion of a series of sutures. Usually it will be advisable to dissect out the suprapatellar bursa in the early stages of the operation, since if it is left it is liable to impede the healing of the wound.

Dressings are applied, and the limb firmly fixed in splints.

Partial excision of the tibia.—Removal of a portion of the diaphysis of the tibia is occasionally required in cases of necrosis of the bone occurring in connection with acute infective osteomyelitis.

The operation is essentially of the nature of a sequestrotomy, and is usually performed after the expiration of some considerable time from the onset of the disease, when the periosteum has formed a sheath of new bone which encloses the dead portion.

Special instruments. — Chisel and mallet, in addition to the ordinary instruments for excision of a bone.

Position.—The patient is placed in the dorsal position, with the affected limb fully extended and lying somewhat upon its lateral side. The operator stands on the outer side of the affected limb, and his assistant opposite to him.

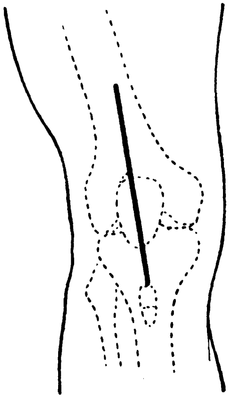

FIG. 453. — Excision of patella. Position of external incision.

Operation.—An incision, usually 3 inches or more in length, is made over the middle of the affected portion of the bone. This is generally done by enlarging one of the sinuses which are already present. The soft tissues are divided down to the bone, and then the "involucrum" of new bone which surrounds the dead portion of the diaphysis is cut through, with chisel and bone forceps, in a vertical direction for the entire length of the incision. The margins of the wound are held apart with retractors, and the enclosed portion or portions of bone extracted with sequestrum forceps. In order to facilitate the removal of the sequestrum, it will usually be found convenient to divide it transversely at the bottom of the incision with a pair of bone forceps, and to remove it in two halves.

The interior of the cavity in the bone from which the sequestrum has been extracted is thoroughly irrigated with saline solution, and then packed with tampons of gauze.

In cases where the periosteum does not give rise to the formation of new bone after the sequestrum has been removed (this most often happens when the sequestrum has been removed too early) it will be necessary to fill up the cavity with a bonegraft taken from the sound tibia.

Excision of the fibula.—*Indications.*—This may be necessary in cases of primary sarcoma of the bone, or more rarely in cases of acute osteomyelitis which has given rise to necrosis of a portion of the bone.

Operation.—A vertical incision is made over the posterolateral border of the bone. The muscles are dissected away from their osseous attachments, and the affected part of the fibula exposed and removed.

The entire fibula may be removed without causing serious interference with the use of the limb.

Excision of the calcaneus (O.T., Os Calcis).—*Indications.*—

(*a*) Tuberculous disease of the calcaneus which is limited to that bone.

(*b*) Tuberculous disease of the talo-calcaneal (calcaneo-astragaloid) articulation involving chiefly the calcaneus.

(*c*) Acute necrosis of the calcaneus, the result of acute osteomyelitis.

(*d*) Sarcoma primary in the calcaneus.

Position.—The patient is placed in the dorsal position, with the affected foot supported on a sandbag with its outer surface upwards. The surgeon stands on the outer side of the affected foot, and his assistant opposite him.

Operation.—An incision is made, commencing at the medial border of the tendo calcaneus immediately above its attachment to the calcaneus and extending across the heel and along the lateral side of the foot to a point ½ inch posterior to the prominence of the fifth metatarsal bone, the tendo calcaneus being detached from its point of insertion. This incision divides all the soft tissues down to the calcaneus. With a strong scalpel the soft tissues at the posterior and lateral margin of the foot and the sole are dissected away from their attachment to the calcaneus in the form of a single flap. The posterior portion of the calcaneus is now grasped with lion forceps, and the entire bone forcibly pulled downwards, so as to render tense the ligaments of the talo-calcaneal joint. This is done by the assistant. The soft tissues at the upper part of the incision are dissected upwards, care being taken not to divide the peronæi muscles, which should be held out of the way with retractors. The middle fasciculus of the fibular collateral (external lateral) ligament of the ankle-joint is cut through, and then the articulation between the distal aspect of the talus and the proximal surface of the calcaneus is opened from the lateral side. The very strong interosseous talo-calcaneal ligament is divided, and then the calcaneus is pulled farther downwards and laterally, and cleared on its medial side. Next, the articulation between the anterior part of the calcaneus and the cuboid is opened, by cutting through the ligaments from above. Finally, the calcaneo-navicular ligaments are divided, and the calcaneus removed.

If more room is required in order to expose the medial aspect of the bone, the incision may be prolonged upwards along the medial margin of the tendo calcaneus.

If the synovial membrane which lies between the talus and the calcaneus is diseased, it is dissected away.

Hæmorrhage having been arrested, the space previously occupied by the calcaneus is packed with gauze, and the external incision partially closed by the insertion of the interrupted sutures.

Excision of the talus (O.T., Astragalus).—

Indications.—(*a*) Cases of complete dislocation of the talus in which the bone cannot be replaced.

(*b*) Some forms of inveterate talipes.

(*c*) Caries of the talus which is either limited to this bone or does not extensively affect the surrounding tissues.

(*d*) Some forms of disease of the talo-calcaneal joint, in which it is thought from the position of the sinuses that the affection chiefly involves the talus and not the calcaneus.

(*e*) Compound dislocation of the talus complicated with fracture, in which the bone cannot be satisfactorily replaced, and the severity of the injury is not sufficient to justify amputation.

(*f*) Sarcoma primary in the talus.

Operation.—An incision from 2 to 3 inches in length is made on the lateral aspect of the ankle (Fig. 454). It commences above immediately medial to the anterior border of the lateral malleolus, and ½ inch proximal to the level of the ankle-joint, and extends in a downward and forward direction to a point on the dorsal and lateral surface of the foot over the cuboid bone, about one inch medial to the prominence at the base of the fifth metatarsal bone. This incision is parallel with and posterior to the tendon of the peronæus tertius, and in front of the peronæus brevis. The skin and fasciæ, together with the lower portion of the anterior annular ligament, are divided until the bones are reached. The margins of the incision are dissected up and pulled well aside with retractors. This will expose the lateral portion of the talus. The anterior fasciculus of the fibular collateral ligament of the ankle-joint and the anterior ligament of the same joint are divided. The foot is well extended and inverted, and the ligaments which fix the talus to the navicular (scaphoid) on the dorsal aspect of the foot cut through. The talus is now seized with lion forceps, pulled strongly laterally, and its ligamentous connections on the medial side of the foot exposed and divided. When this has been done the bone can be pulled farther laterally, and its posterior ligamentous attachments and the strong interosseous talo-calcaneal ligament cut through. The bone is now free, and can be removed. It should be remembered that no muscles are attached to the talus.

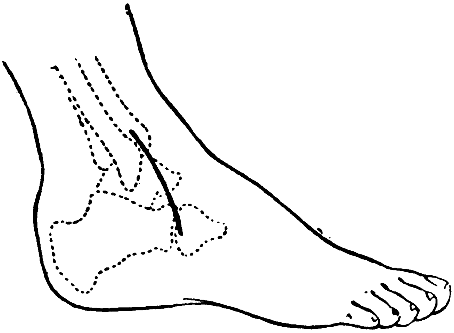

FIG. 454.—Excision of talus (astragalus). Skin incision.

The talus can usually be removed in this manner in cases of talipes, or of dislocation of the bone as a result of injury.

In removal of the bone for disease, however, the above incision does not give a sufficiently free exposure. In such cases a second incision is made on the medial side of the foot, immediately behind the tendon of the tibialis posterior.

When the bone has been removed a gauze drain is placed in the interior of the wound, and the incision is closed by the insertion of interrupted sutures.

Excision of a wedge-shaped piece from the tarsus (cuneiform tarsectomy).—*Indications.*—An operation of this nature, involving the excision of a wedge-shaped piece from the tarsus, is necessary in certain forms of talipes equino-varus, talipes equinus, and talipes valgus, in which the bones themselves are considerably malformed, and in which other methods of treatment are not productive of a satisfactory result.

In cases of talipes equino-varus the base of the wedge is situated on the lateral and superior aspect of the foot, and comprises for the most part the cuboid bone. The apex is situated at the navicular on the medial side.

In talipes equinus the base of the wedge is towards the dorsum of the foot and the apex towards the sole.

In talipes valgus the base of the wedge is towards the inner margin of the foot.

The amount of bone which it is necessary to remove in these cases varies according to the amount of malformation present.

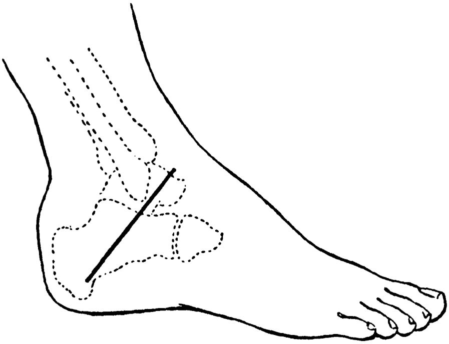

FIG. 455.—Cuneiform tarsectomy. Position and direction of external incision.

Often, however, it is requisite to take away portions of the cuboid, talus (astragalus), and navicular (scaphoid), and occasionally of the other tarsal bones.

Special instruments.—Periosteal elevator, chisel and mallet.

Operation.—In the majority of instances, removal of a wedge-shaped portion of bone is effected through an incision situated upon the lateral side and dorsal aspect of the foot over the most prominent part of the deformity.

An incision is made which commences over the dorsal and lateral aspect of the talo-navicular joint, and extends downwards, laterally, and backwards towards the sole and the prominence of the heel (Fig. 455). This incision divides the skin and superficial fasciæ; the cutaneous portion of the superficial peronæal (musculo cutaneous) nerve is sought for and defined at the medial angle of the wound, and the small saphenous nerve at the lateral angle. When these nerves have been defined they are retracted to the medial and lateral sides respectively. The deep fascia is then cut through, and the muscles exposed. In the medial angle of the wound the peronæus tertius will be seen ; in the lateral angle, the peronæus brevis and the proximal border of the extensor brevis digitorum. These muscles are retracted to the medial and lateral sides respectively, and the dorsal aspect of the tarsal bones exposed. The ligaments which fix these bones together are separated with the periosteal elevator, and the base of the wedge-shaped portion of bone which it is wished to remove exposed. This will usually consist of the greater part of the cuboid, the lateral and anterior portion of the calcaneus, and the head of the talus, with possibly a small piece of the navicular. When the bones have been sufficiently cleared and freed from their ligamentous connections, the chisel and mallet are taken, and the portions of bone comprising the wedge removed.

Any adventitious bursa which has developed should, if thick-walled and conveniently reached, be dissected out and removed.

All bleeding having been arrested, the cut surfaces of bone are brought into apposition and the external wound closed in the usual manner. The limb is fixed in the rectified position on a suitable splint. After a few days the dressings are removed, the stitches taken out, and the limb encased in plaster.

Excision of a metatarsal bone, or of a phalanx.—Excision of these bones differs in no essential respect from that of the corresponding bone of the upper extremity. In the case of a metatarsal bone, the incision is generally on the dorsal aspect of the foot ; in the case of a phalanx, at the side.

CHAPTER XXVIII

OPERATIONS ON JOINTS

I. REMOVAL OF SEMILUNAR CARTILAGE FROM KNEE-JOINT

Operation for the removal of the internal meniscus (semilunar cartilage).—*Indications.*—In cases of fracture, tearing, or dislocation of the meniscus which is not cured by rest and which results in periodic "giving way" of the joint. Operation is contra-indicated in old-standing cases associated with much arthritis.

Choice of operation.—The patient may be operated upon with the injured limb lying fully supported upon the operating table, or the limb may be flexed at the knee-joint with the leg hanging over the end of the table.

Operation.—*Special instruments.*—Blunt hook, sharp hook, narrow-bladed curved scissors, tourniquet.

Position.—The patient lying in the dorsal position with the injured knee slightly flexed and lying upon its outer side supported by a sandbag. The surgeon stands on the outer side of the injured limb, and the first assistant opposite him. A second assistant grasps the foot and manipulates the leg as directed by the surgeon.

Operation.—The affected limb is emptied of blood and a tourniquet applied in the middle of thigh. A curved incision with the concavity upwards is made, starting at the lateral margin of the anterior patella ligament near its inferior attachment and extending upwards and slightly forwards as far as the anterior edge of the lateral ligament of the knee-joint. This incision cuts through skin and fascia and exposes the capsule of the joint. The capsule anterior to the internal lateral ligament is divided in the direction of its fibres, and the synovial membrane incised in the direction of the original incision. A gridiron opening into the joint is thus effected. If any large vessel has been cut across, its ends are ligatured with fine catgut. The edges of the wound are retracted and the meniscus inspected. The anterior horn is detached with a fine scalpel and pierced by the sharp hook. Traction is made upon the hook, and the attachment of the cartilage to the internal ligament divided. The knee is now flexed by the assistant and the foot everted, the tibia at the same time being pushed forwards. It is now possible for the surgeon to divide the posterior horn of the cartilage with fine curved scissors. The cartilage thus freed from its attachment is removed. A careful inspection of the synovial fringes is next made and any irregularities dealt with. The synovial membrane is closed with a continuous suture of fine catgut; the capsule, with interrupted sutures of coarser catgut. The skin is sutured with silkworm gut, without drain. A dressing is applied, and the knee firmly bandaged over a thick pad of cotton wool. The tourniquet is next removed and a back splint applied.

After-treatment.—The patient should be kept in bed upon the splint for eight to ten days. The skin sutures are then removed and the patient allowed to walk with the splint still worn for a week, during which time he should have passive movements to the knee daily. The splint is discarded in the third week, and by the end of the sixth week recovery should be complete.

Another method (Robert Jones).—*Position.*—The patient lies in the dorsal position with the injured limb hanging flexed over the end of the table. The sound limb hangs over the side of the table and is tied out of the way. The operator sits on a stool opposite the end of the table and supports the foot of the injured limb in his lap.

Special instruments, as above.

Operation.—A curved incision is made 2 inches in length, starting ½ inch internal to the inner edge of the patella at its centre, curving downwards and backwards until it reaches the level of the joint, and then running parallel to the upper articular surface of the tibia. This incision divides the skin and fascia only. A second incision is made similar to the first, cutting through the lateral patella ligament, care being taken to avoid injury to the anterior fibres of the internal lateral ligament.

The synovial membrane is opened and the meniscus dealt with as described in the previous operation. The wound is closed in layers, catgut being used for the synovial membrane, and the capsule and silkworm gut for the skin.

The after-treatment is the same as already described. When the external semilunar cartilage is the one which is split or partially detached—a condition which only very rarely occurs—the incision should be made on the outer side. Otherwise the details of the operation are similar to those described above.

Removal of a "loose body," or "cartilage," or detached fragment of bone from the knee-joint.

The position of the patient, etc., are the same as for removal of a meniscus.

Operation.—The knee-joint is opened by a vertical incision on either side of the patella, according to the position of the "loose body," if it has been located; if not, on the medial side. When the joint cavity has been opened the margins of the wound are retracted, "the loose body" or cartilage sought for and removed. If not readily found, the entire joint cavity can be flushed with warm saline solution so as to wash out the "loose body" or "bodies." When this has been done, the wound is closed by suture—the synovial membrane being first sutured with catgut.

Removal of the meniscus from the temporo-maxillary joint.

Indications.—(*a*) "Clicking jaw."

(*b*) In some cases of recurrent dislocation of the temporo-maxillary joint where dislocation is apparently due to a split or displaced meniscus.

(*c*) Recurrent locking of the temporo-maxillary joint due to displaced or split meniscus.

Position.—The patient is placed in the dorsal posture on the operation table with the head turned to the sound side. The operator stands on the affected side of the patient and his assistant directly opposite to him.

Operation.—An incision two-thirds to one inch in length is made, which commences above at the lower margin of the zygoma at a point slightly in front of the anterior margin of the external auditory meatus and extends vertically downwards. This incision first divides skin and fasciæ and exposes the external surface of the parotid salivary gland. While making this incision care should be taken to avoid any of the branches of the facial nerve which pass upwards or upwards and forwards, and also the superficial temporal artery. When the superficial aspect of the upper and posterior portion of the parotid salivary gland has been defined by careful dissection, the posterior margin of the gland is laid bare. Next, the exposed portion of the parotid salivary gland is retracted forwards with a small retractor and the posterior portion of the skin incision backwards. The external or lateral aspect of the temporo-maxillary joint will now be seen exposed in the bottom of the wound. Careful palpation may in some cases show that the meniscus has been split and a portion felt displaced forwards and upwards. The capsular ligament of the temporo-maxillary joint is then incised in a vertical direction, and the joint carefully opened. When this has been done the meniscus can be readily recognised and seized with a pair of strong toothed forceps. Traction should be then exerted to bring it into the deeper portion of the wound, and by cutting with a fine scalpel any fibrous tissue connections can be severed. By this means the entire meniscus can be excised. When this has been done the margins of the incision in the capsular ligament are united by a suture of catgut. Next, the posterior and upper portion of the parotid salivary gland is allowed to fall into its proper position and the external wound is closed.

In some cases, where the parotid salivary gland extends for some distance posteriorly, it may be necessary to incise gland substance instead of pulling forward the posterior portion of the gland, which has been described above.

II. Excision of Articulations

By the term "excision of an articulation or joint" is understood the removal from the body, by the performance of a surgical operation, of a part or the whole of the tissues which enter into the formation of the joint which is under consideration.

Thus it generally happens that part or the whole of the ligaments, synovial membranes, interarticular fibro-cartilages, and articular surfaces and extremities of the bones are removed.

When only a part of the anatomical elements which enter into the formation of the joint are taken away the operation is called a "partial excision"; and when all these tissues are removed it is known as a "complete excision." The partial operations are more commonly performed than complete ones, except in the case of tuberculous disease, when it occasionally happens that the whole of the joint tissues are excised.

Several distinct methods of performing "excision of a joint" are practised. These are generally known as—

(*a*) The open method.
(*b*) The subperiosteal subcapsular method.
(*c*) The osteoplastic method.

These different methods will now be separately discussed, and afterwards the excisions of the various individual joints will be described.

(*a*) *The open method.*—In the open method of performing excision of a joint an incision is made through the soft tissues overlying the articulation in order to expose the diseased tissues and enable the surgeon readily to remove them. When the external surface of the capsular ligament has been reached the soft tissues are turned aside by dissection, and the ligaments together with the articular extremities of the bones laid bare. The periosteum is left attached to the bones. This having been done, the articulation is excised, the ligaments and portions of bone with their periosteum being taken away. This is the method used in extensively diseased joints, in which the disease has extended to all the tissues entering into the formation of the articulation. If only a portion of the joint elements are taken away the operation is a " partial excision," performed according to the *open* method.

(*b*) *The subperiosteal subcapsular method.*—In this method of operation the periosteum which covers the upper portions of the bones entering into the formation of the joint, and the capsular ligament with its localised thickenings, are turned aside at the same time as the more superficial soft tissues; the diseased synovial membrane and articular surfaces of the bones are removed, and finally the periosteum and the capsular ligament are replaced in their former positions. In order to do this effectively the first incision is prolonged through the capsular ligament and the periosteum with which it is continuous, and then, with a rugine or a periosteal elevator, these structures are stripped from their attachments to the bones and turned aside. When this has been done the interior of the joint cavity is exposed, and all diseased synovial membrane and articular cartilage can be removed. An excision performed according to this method is in reality a partial excision.

This form of operation is applicable to those cases of joint disease in which the synovial membrane and the articular cartilages are alone involved, as in the early stages of " tuberculous disease of joints," in some forms of joint affection dependent upon traumatic causes, and in some forms of ankylosis. It is not available in cases of extensive disease due to tuberculosis, or in any case of malignant disease of the bone, since in every case of this nature the periosteum must be removed.

(*c*) *The osteoplastic method.*—In addition to turning aside the periosteum of the articular extremities of bones and the ligaments, an attempt is made in "osteoplastic excision" temporarily to detach the bony prominences (tubercles, tuberosities, condyles, or trochanters) with the muscles and ligaments still fixed to them. This is effected by exposing the articulation as in the previous method, and then with a chisel and mallet the portions of bone to which the muscles and the ligaments, especially the lateral ones, are attached are chiselled through and turned aside, together with their attached soft tissues. When the diseased tissues from the interior of the joint have been removed, the bony prominences are fixed in their original position by means of bone or ivory pegs, or by sutures of silver wire or strong catgut. This method of performing excision of a joint is of very limited application, and can only be made use of in some forms of ankylosis, and in traumatic affections.

The term "arthrectomy" is sometimes employed in place of "excision of a joint," complete excisions being known as "complete arthrectomies," and partial operations as "partial arthrectomies."

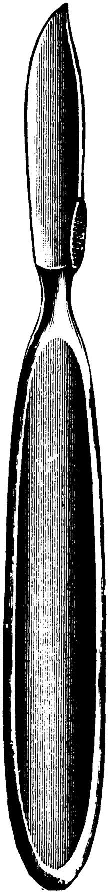

FIG. 456.—Resection knife.

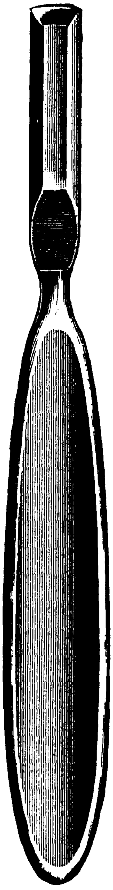

FIG. 457.—Periosteal elevator.

Arthrotomy is applied to that operation which consists in the incision of a joint, as for the evacuation of a collection of fluid, or the removal of a loose body. Arthrotomy, moreover, is the first stage in all partial or complete excisions.

Indications for excision of joints.—(*a*) Tuberculous disease of a joint, which is not improving under ordinary palliative measures.

(*b*) Ankylosis of a joint, which either renders it useless on account of its immobility or fixes it in a useless position. This group includes (1) cases of fibrous ankylosis of a joint such as the knee, where firm bony union can alone give a really useful limb, and (2) cases of fibrous or bony ankylosis, such as in the shoulder, where it is desirable to obtain a movable joint.

(*c*) Some forms of injury to a joint, when there has been much splintering of bone, or when the fracture into the joint is comminuted, and the fragments cannot be replaced in position.

(*d*) Ecchondroses or exostoses of the articular extremities of long bones which extend into the joint cavity, and so make the articulation practically useless.

(*e*) Some forms of displaced or torn interarticular cartilages, such as the menisci of the knee-joint, which are not suitable for fixation, and can only be satisfactorily dealt with by removal.

Arthrotomy is necessary for the removal of loose bodies, foreign bodies, detached portions of articular cartilage, displaced or dislocated interarticular cartilages, and for the evacuation of fluid collections within the joint cavity which cannot be satisfactorily dealt with in any other manner.

Special instruments.—The instruments which are necessary for the excision of a joint are similar in nearly all instances, the chief difference being the form of saw and the size of the knife.

The following are requisite :—Resection knife, lion forceps, chisel and mallet, periosteal elevators, saw, and Volkmann's spoon. Suitable splints are also necessary.

The individual operations for the excision of joints will now be considered seriatim.

Excision of shoulder-joint.—The shoulder-joint is the articulation between the glenoid cavity of the scapula and the head of the humerus. In performing an excision of this joint it may be necessary to remove either a part or the whole of the structures which enter into its formation. Usually, however, the operation is of the nature of a " partial arthrectomy."

Position.—The patient is placed in the dorsal posture, with the affected shoulder somewhat raised and projecting slightly over the margin of the table, and the limb drawn slightly outwards. The surgeon stands on the outer side of the diseased shoulder, the first assistant grasps the limb at the elbow (so as to be able to rotate it as required), and the second assistant takes up a position on the left of the operator.

Operation.—An incision is made which commences at the lower margin of the clavicle opposite the lateral border of the coracoid process, and extends distally in a direction parallel to the anterior margin of the deltoid muscle for a distance of about 3½ or 4 inches. This incision lies over the medial fibres of the deltoid muscle (Fig. 458). The skin and fasciæ are divided, care being taken to avoid the cephalic vein, which lies in the groove between the deltoid and pectoralis major muscles. This interval is defined if possible, and the cephalic vein pulled over towards the medial side, or, if the deltoid cannot be easily retracted laterally, its medial fibres are cut through. The pectoralis major is retracted medially, and the deltoid laterally, the latter muscle being divided transversely immediately distal to its origin from the clavicle, if it is found to be necessary, in order to obtain a clear and uninterrupted view of the shoulder-joint. A muscular branch of the acromial branches of the thoraco-acromial artery may require ligature at this stage. When those muscles have been well drawn aside by retractors, the antero-medial aspect of the capsular ligament will be visible in the bottom of the wound. The humerus is now rotated medially by the assistant, so as to bring the intertubercular groove of the humerus and the long tendon of the biceps brachii into view. The capsular ligament of the joint is divided along the medial margin of the biceps tendon, together with the transverse humeral ligament which bridges over the intertubercular groove and helps to hold the tendon in position. By this procedure the biceps tendon is separated from its sheath. With a retractor or blunt hook this tendon is drawn laterally, and at the same time the humerus is laterally rotated by the

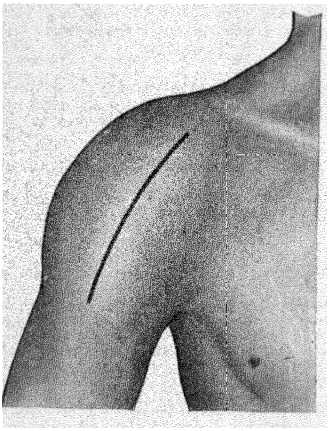

FIG. 458.—Excision of shoulder-joint. Anterior incision.

ssistant. This brings forward the medial or small tuberosity f the humerus, together with the insertion of the subscapularis nto it. This is separated from the bone either with a scalpel or periosteal elevator. If the scalpel is used, a series of cuts is nade parallel with the intertubercular groove. Next, the iceps tendon is drawn towards the medial side, and the humerus s medially rotated by the assistant, so as fully to expose the ateral or large tuberosity with its attached muscles. These are he supraspinatus, the infraspinatus, and the teres minor, in this rder from above distally. They are separated from their sseous connections in the same way as the subscapularis, are being taken not to divide the capsular ligament of the rticulation in a transverse direction. In those cases in which he disease is limited to the synovial membrane and the articular xtremities of the bone it may be possible to detach the tubersities with a chisel, and to turn them aside with their muscles ttached to them. When the removal of the affected tissues as been accomplished the tuberosities can be fixed in their riginal positions by the insertion of a few sutures. When the ead of the humerus, together with as much of the shaft as is equisite, has been exposed, the proximal extremity of the bone s forced out of the external wound and sawn across distal to the iseased area. In some cases it is possible to saw through the natomical neck, while in others the surgical neck must be cut. Vhen the proximal extremity of the bone has been removed the nargins of the cut surface are rounded off, so as to make a kind f artificial head to the bone. Next, all traces of diseased ynovial membrane are removed, and then the glenoid cavity of he scapula is examined. If this is affected the diseased portion s removed by bone forceps or a sharp spoon.

The interior of the articulation is now irrigated so as to remove ll bone dust or other débris.

A drainage tube is passed into the bottom of the wound, and he external incision is closed.

After-treatment.—The limb is supported in a sling for ten ays (or a fortnight), and then passive movements are comnenced. These must be continued daily until the functions of he joint have become more or less completely restored. It is dvisable to commence passive movements of the distal parts of he affected limb a day or two after the operation has been erformed.

Some surgeons have made use of a posterior longitudinal ncision for excision of the shoulder-joint, and others a U-haped flap, the deltoid muscle being turned upwards, whilst others again have made a curved posterior incision and sawn through the acromion. None of these methods seems to be so satisfactory as the one described above, and they cause much more impairment of the functions of the limb.

Excision of elbow-joint.—Three bones enter into the formation of the elbow-joint,—the distal end of the humerus and the proximal extremities of the radius and ulna. The proximal radio-ulnar joint is usually affected in diseased conditions of the elbow-joint, and requires excision as well.

An excision of the elbow-joint is in most cases complete, but occasionally it may be advisable to perform a partial operation.

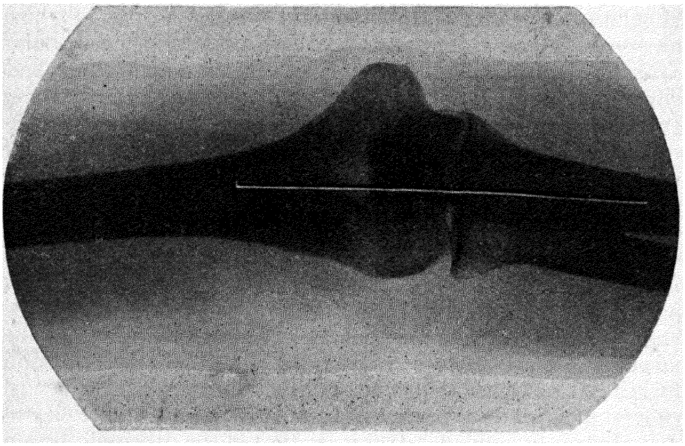

FIG. 459.—Position of external incision in resection of right elbow-joint.

Position.—The patient is placed in the dorsal posture, with the affected arm semiflexed at the elbow and resting upon the trunk. The hand is in a position of partial pronation. The surgeon stands on the outer side of the affected elbow, and his assistant on the opposite side of the patient.

Operation.—An incision from 4 inches in length is made along the posterior aspect of the limb, slightly nearer the medial than the lateral margin (Fig. 459). This incision commences on the dorsal aspect of the forearm about 2 inches distal to the elbow-joint, and extends proximally to a similar distance above. The prominence of the olecranon is situated opposite the middle of the incision. The skin, fasciæ, and muscles are divided down to the posterior aspect of the bones. In the proximal half of the incision the triceps is cut through, and in the distal half the fibres of the anconæus near the posterior border of the ulna are exposed. A flap, consisting of skin, fasciæ, and muscles is now dissected from the bones towards the lateral side. In making this flap the edge of the excision knife, or the periosteal elevator, should be kept close to the bone, and all cuts made parallel with the external incision. This flap consists above of one-half of the triceps brachii, the upper part of the anconæus, and the origins of the extensor muscles which are attached to the lateral epicondyle of the humerus, and distally of the rest of the anconæus and the continuation downwards of the extensor muscles. If the disease has not extended to the lateral epicondyle this process of bone may be cut through with a chisel, and the attachments of the extensor muscles partially preserved.

Next, a similar flap is turned up from the medial side. In dissecting up this flap, great care must be taken not to injure the ulnar nerve. It lies in the groove upon the posterior aspect of the medial epicondyle of the humerus. If the edge of the knife is kept close to the bone, and each cut is made in the direction of the course of the nerve, there is little risk of injuring it. The medial epicondyle is cleared in a manner similar to the lateral, or in suitable cases it may be cut through and turned aside with the muscles attached.

The joint is flexed by the assistant, and then the posterior part of the capsular ligament is cut through immediately proximal to the olecranon, and the joint cavity opened. The lateral ligaments are usually turned aside along with the muscles. The extremities of the bones are now turned out, and fully exposed. A few slight cuts with the knife will sufficiently free them from the soft tissues, and then they are ready for the performance of " bone section."

The assistant who has charge of the arm thrusts upwards the forearm, so as to make the proximal extremities of the radius and ulna project beyond the distal end of the humerus. The olecranon is then grasped by an assistant with a pair of lion forceps, and steadied whilst the surgeon removes it by cutting through the bone at the bottom of the articular cavity with bone forceps. The distal end of the humerus is now protruded, further separated if necessary, the trochlear portion grasped with lion forceps, and the section made with the saw along a plane which is above the articular surface. The base of the olecranon, together with the articular portion of the coronoid, is removed with the saw and also the head of the radius, below the articular surface, but above the attachment of the biceps tendon. The epiphyseal line is proximal to the level of the section in nearly all cases. When the bones are being divided with the saw the soft parts should be protected from injury by broad flat retractors held by an assistant.

When the articular ends of the bones have been removed the space which is exposed is examined for portions of diseased tissue, and if any are found they are removed by scraping with a sharp spoon.

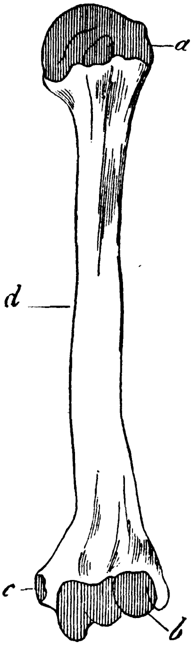

Fig. 460.—Humerus, showing the parts of the bone derived from the several centres of ossification.

a. Proximal epiphysis.
b. Distal epiphysis.
c. Centre for medial epicondyle.
d. Shaft.

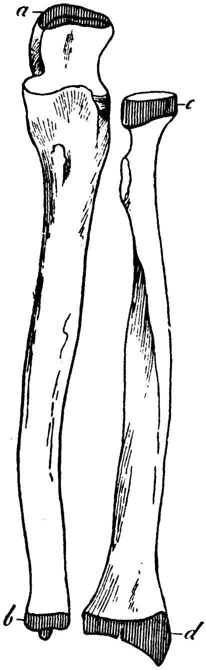

Fig. 461.—Radius and ulna, showing the parts of the bones derived from the several centres of ossification.

a. Proximal epiphysis of ulna.
b. Distal epiphysis of ulna.
c. Proximal epiphysis of radius.
d. Distal epiphysis of radius.

All bleeding is arrested, and the external wound closed by the insertion of a series of interrupted sutures. If a large cavity has been made owing to removal of considerable quantities of tissue, or if there is much oozing of blood from the incised surfaces, a drainage tube is passed into the bottom of the wound, and the free extremity brought through an angle of the external incision left open for the purpose.

Dressings are next applied, and the limb placed in a right-angled position and bandaged to a splint; or it may be fixed to a straight splint, and kept in the extended position for the first few days. In all probability the latter method is the better.

After-treatment.—The limb is maintained at rest for two days, and then passive movements of the finger and the wrist are commenced. At the expiration of seven to ten days passive movements at the elbow are commenced, and continued daily until good movements have been restored. It is often necessary, especially in the case of children, to place the patient under an anæsthetic before commencing these movements at the elbow-joint.

There appears to be less risk of producing a "flail-like" joint when the limb is put up in the extended position than when it is placed on a right-angled splint.

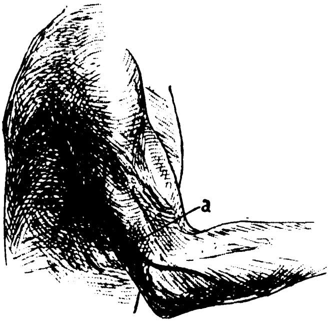

FIG. 462.—Excision of elbow-joint, through a lateral incision.

a. Position of skin-incision.—After KOCHER.

Excision of the elbow-joint through a lateral slightly curved incision.—Kocher recommends that an incision 5 inches in length should be made on the lateral side of the arm. It commences at a point opposite the upper part of the lateral supra-condylar ridge of the humerus, and 2 inches proximal to the level of the articulation, and extends distally along the lateral aspect of the limb as far as the head of the radius; then it crosses the extensor aspect of the forearm in an oblique direction to a point on the posterior border of the ulna about 3 inches distal to the elbow-joint,—this part of the incision corresponds to the distal and lateral margin of the anconæus muscle; the incision terminates by curving medially for a short distance (Fig. 462). The incision is extended to the bones and the lateral aspect of the elbow-joint. In its proximal part it passes between the lateral head of the triceps posteriorly and the brachio-radialis (supinator longus) and extensor group of muscles anteriorly; and in its lower segment it is situated between the outer margin of the anconæus posteriorly and the extensor carpi ulnaris anteriorly. The radial collateral (external lateral) ligament, the lateral part of the ligament of the radius, and the adjacent portion of the capsule which is attached to the lateral epicondyle are detached and retracted forwards. The forearm is next forced inwards, so as to dislocate the articular surfaces outwards. The ulnar collateral (internal lateral) ligament is next separated, and then the excision of the joint can be readily performed.

The triceps brachii and the anconæus are separated from the bone, the olecranon being cut through, if not too extensively diseased, and drawn towards the medial side, in the form of a flap. This gives a good exposure of the joint. The bones are then sawn as in the previous chapter.

Kocher recommends that the olecranon should be sawn in a curved direction, so as to preserve a lever for the action of the triceps muscle, and help to prevent the partial dislocation of the forearm forwards.

Other incisions have been advocated for exposing the elbow-joint in excisions, but none of them are so satisfactory as the two above described, and in my opinion the operation first-mentioned is the one to be preferred in nearly all cases.

Excision of the radial portion of the proximal radio-ulnar joint (excision of the head of the radius).—This operation is occasionally necessary in old-standing cases of dislocation of the head of the radius, in which the bone cannot be replaced and maintained in its normal position, and in which there is considerable impairment of flexion of elbow-joint.

Operation.—The position of the head of the radius is first defined, and then a vertical incision 2 inches or more in length is made over the most projecting portion of the bone, and in a direction parallel with the long axis of the forearm. This incision is deepened until the bone is reached. The annular (orbicular) ligament which surrounds the head of the radius is divided, and the soft tissues held aside with retractors. The radius is next cut through at the level of its neck either with a fine saw or bone forceps, or a Gigli's wire saw. The section should be made above the tubercle of the radius, and care should be taken to avoid injury to the superficial and deep branches of the radial (musculo-spiral, *i.e.* radial and posterior interosseous) nerve.

In the after-treatment, passive movements must be commenced immediately the external wound has healed, so as to avoid the formation of adhesions and the limitation of movement.

Excision of the wrist.—The wrist-joint, from a surgical point of view, may be considered to comprise the series of articulations which lie between the distal extremities of the radius and the ulna and the proximal ends of the metacarpal bones. There are in reality three transverse joints included under this term,—the radio-carpal joint, the transverse carpal joint, and the carpo-metacarpal joint,—in addition to the small joints between the individual bones of each row of the carpus. There are six (sometimes only five) separate synovial membranes in connection with these joints, the extent of which is shown in Fig. 463. An incision may be either complete or partial, according to the number of bones removed.

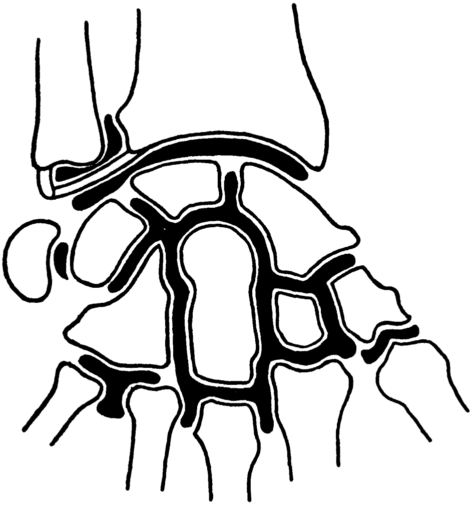

Fig. 463.—Synovial membranes of the carpus.

The operation has been performed for tuberculous disease of the wrist, for injuries such as compound fractures and dislocations and gunshot wounds, and in some forms of rheumatic affections of the joint.

Position.—The patient lies on the operation table in the dorsal posture, with the affected limb at right angles to the trunk, and resting upon a second smaller table. The operator seats himself opposite the affected hand, his assistant being opposite him.

Many operations have been practised for excision of the wrist. The best appear to be those which are performed through dorsal incisions, and the most satisfactory of these is the one described by Ollier. The following operation is based upon Ollier's method :—

Operation.—Excision of the wrist may be divided into the following stages :—

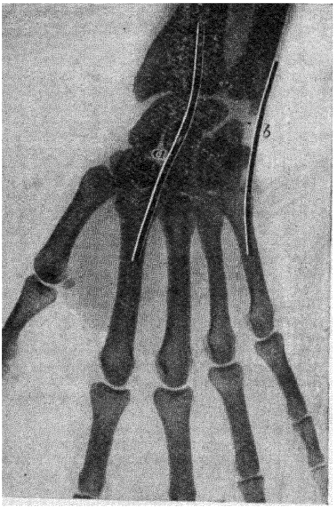

FIG. 464.—Excision of wrist. Skin incisions.

a. Lateral incision.
b. Medial incision.

(*a*) *Skin incisions and exposure of the bones.*—Two incisions are made, one on the radial and the other on the ulnar side of the dorsal aspect of the limb.

Radial incision.—The radial incision commences on the dorsal surface of the second metacarpal bone at a point opposite the middle of the shaft, and extends proximally along the lateral margin of the most lateral tendon of the extensor digitorum communis to a point situated at the centre of a line joining the styloid processes of the radius and ulna. Beyond this level it is prolonged upwards in a vertical direction for about 1 inch or a little more (Fig. 464, *a*). This incision measures about 3 or 4 inches in length, one-third being situated proximal to the line joining the two styloid processes, and two-thirds distal to it. It divides the skin and fasciæ with some of the fibres of the posterior ligament of the wrist, and lays bare the most lateral tendon of the extensor digitorum communis. This muscle is retracted towards the medial side, and the incision deepened until the bones are reached, care being taken not to divide the tendon of the extensor carpi radialis brevis, which is inserted into the dorsal aspect and lateral side of the base of the third metacarpal bone. In the proximal part of the incision it is necessary to separate the lateral margin of the extensor proprius indicis from the medial border of the extensor pollicis longus (extensor secundi internodii pollicis), which can be recognised by its oblique direction. The extensor proprius indicis and the extensor digitorum communis are drawn towards the medial side with retractors, and the extensor pollicis longus (extensor secundi internodii pollicis), and the extensor carpi radialis brevis towards the lateral side. With the periosteal elevator or rugine the dorsal aspect of the bones is laid bare by detaching the posterior ligaments and the periosteum.

Medial incision.—An incision is made along the lateral margin of the tendon of the extensor carpi ulnaris, commencing at a point opposite the middle of the shaft of the fifth metacarpal bone, and extending proximally to a point about 1 inch or a little more above the prominence of the styloid process of the ulna (Fig. 464, *b*). The skin and fasciæ are divided, care being taken to avoid the branch of the ulnar nerve to the dorsum of the little finger, and the interval between the extensor carpi ulnaris and the extensor digiti quinti (extensor minimi digiti) exposed. These muscles are exposed and pulled aside, the former towards the medial margin of the limb and the latter towards the lateral. The dorsal aspect of the lower portion of the ulna, the os triquetrus (cuniform), the os hamatum (unciform), and the proximal part of the fifth metacarpal bone, will now be exposed. The ligaments and periosteum are divided with the scalpel, and then separated from their bony attachments with the rugine.

(*b*) *Removal of the bones.*—When the carpal bones have been separated from their periosteal and ligamentous connections, each one is seized separately with forceps and removed. It is most convenient to remove the bones from the lateral side of the carpus first, and then to remove those on the medial side through the medial incision. On the lateral side the large multangular (trapezium, O.T.) bone should be left if it is not diseased. The articulation between this bone and the base of the first metacarpal has a separate synovial membrane, hence it often happens that it can be safely left. The pisiform bone may be disarticulated, and the hook of the os hamatum (unciform) cut through, and both left if not diseased.

Removal of the extremities of the radius and ulna.—The shafts of these bones are now cleared of their periosteum for about half an inch, or a little more if requisite (according to the extent of the disease process), and then made to protrude through the lateral incision. With a narrow saw the ends are removed beyond the limits of the articular surfaces. If they are not extensively affected it may be sufficient to scrape them with a sharp spoon.

Removal of the proximal extremities of the metacarpal bones.—These are protruded through one of the dorsal incisions, usually the medial, and the articular ends removed with a fine saw. The section of these bones is generally made just beyond the articular surfaces. The connection of the first metacarpal with the distal surface of the large multangular (trapezium, O.T.) bone is not interfered with if possible.

(*c*) *Closure of the external wound.*—The cavity from which the bones have been removed is sponged dry, freed from all bone débris, and the margins of the skin incisions united by the insertion of a number of interrupted sutures. Part of the medial incision is left open, and through this a short drainage tube is passed inwards. Dressings are then applied.

The limb is fixed in a position of slight dorsiflexion, with the fingers gently flexed, by the application of a splint of suitable shape. Fig. 465 is a form of splint which will be found to answer the purpose.

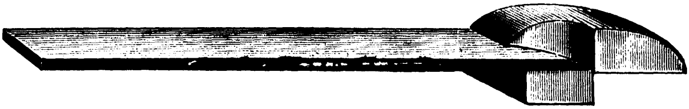

FIG. 465.—Excision of wrist. Splint for use after operation.

The fingers should be passively moved during the time that a splint is worn. In most cases it is necessary for the patient to wear the splint from three to six months.

When the splint has been discarded the patient should wear a leather wristlet.

The results of excision of the wrist-joint have not been good. A certain number of cures have been effected, but often especially when the operation is performed for tuberculous disease of the carpus, the disease recurs, necessitating a second excision or an amputation.

Excision of a metacarpo-phalangeal joint.—This operation is occasionally performed, most commonly in connection with the metacarpo-phalangeal joint of the thumb or that of the little finger.

Operation.—An incision from 1½ to 2 inches in length is made along the lateral aspect of the affected joint, the centre of the incision being opposite the joint. The incision should be situated a little nearer the dorsal than the palmar aspect of the digit.

The soft tissues are divided down to the bone, the lateral ligament is divided, and the periosteum and the tendons turned aside. The ends of the metacarpal bone and the phalanx are protruded through the incision and then removed with a fine saw.

In the case of the thumb the incision is placed on the lateral side, in the little finger on the medial side, and in the case of the other metacarpal bones on either the lateral or the medial side, whichever is the more convenient.

The incision is closed with sutures, and the finger fixed to an anterior splint. As soon as the wound has healed passive movements are commenced, usually at the end of a week or ten days.

Excision of an interphalangeal joint.—This operation is similar to the one described for a metacarpo-phalangeal joint. In some cases the operation will be facilitated by making an incision on each side of the joint. Usually, however, one lateral incision will be found sufficient.

Excision of the hip-joint.—The hip-joint is the articulation between the head of the femur and the acetabular cavity of the hip bone. The capsular ligament of the joint is attached above to the rim of the acetabulum and the transverse ligament which bridges over the acetabular notch, and below to the anterior spiral line in front, and the neck of the femur half-way between the margin of the articular surface and the intertrochanteric crest behind. From this it will be understood that the ligamentous attachments and the synovial membrane of the joint extend much farther down the femur anteriorly than posteriorly. The anterior portion of the capsule is much thickened by the ilio-femoral ligament. In the interior of the joint there is a ligament fixing the head of the bone to the margin of the acetabular notch. This is called the ligamentum teres. A large bursa, which is called the psoas bursa, is situated between the anterior aspect of the joint and the deep surface of the ilio-psoas muscle. This often communicates with the cavity of the hip-joint through an aperture in the anterior portion of the capsule.

An excision of the hip-joint is usually only partial, the femoral elements being the parts which are generally removed. The joint requires excision most commonly in tuberculous affections, and also more rarely for ankylosis in a faulty position, or for inflammatory affections, and in some cases of gunshot wounds. Ankylosis of this joint in a faulty position is better treated by osteotomy of the femur, as described on page 638.

Excision of the hip-joint may be carried out (*a*) through a postero-lateral incision, or (*b*) through an anterior incision. The former is more suitable for extensive operations, and the latter for the less severe ones in which the disease is limited to the upper part of the femur.

Excision of the hip-joint through a postero-lateral incision.—*Position.*—The patient lies upon the sound side, with the diseased hip-joint flexed at half a right angle. The operator stands behind the patient, the chief assistant opposite to him, and a second assistant at the foot of the table holds the affected limb of the patient.

Operation.—The operation may be divided into the following stages :—

(*a*) *External incision and exposure of capsule.*—An incision about 5 to 6 inches in length in an adult or 4 inches in a child is made, commencing at the distal border of the large trochanter of the femur somewhat nearer the anterior than the posterior border, and extending proximally and backwards towards the posterior superior spine of the ilium (Fig. 466). The proximal portion of this incision should be parallel with the direction of the fibres of the glutæus maximus muscle, and may be slightly curved if necessary. This incision divides the skin, fasciæ, and gluteal aponeurosis in the lower half, and the glutæus maximus in the upper. These structures, after being divided, are held aside with retractors, and the interval between the proximal border of the piriformis and the distal border of the glutæus medius muscle sought. When found this is opened up and the capsule of the hip-joint laid bare. The assistant who has charge of the limb rotates it laterally, so as to bring the anterior part of the large trochanter into the wound. The surgeon then separates the attachments of the glutæus medius and minimus from the lateral and anterior aspects of the bone with a rugine. The limb is next rotated medially, and the piriformis, obturator internus and two gemelli, and the obturator externus, are separated in a similar manner. The obturator externus is inserted into the bottom of the trochanteric fossa of the femur, and the other muscles to the top of the trochanter.

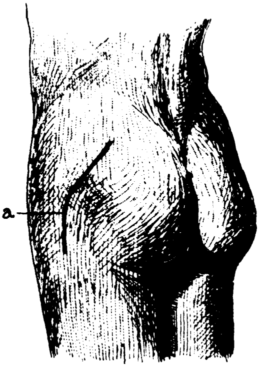

FIG. 466.—Excision of hip, through a postero-lateral incision.

a. Position of incision.

(*b*) *Division of capsule and exposure of the interior of the joint.*—The capsular ligament is incised in a direction parallel with the upper border of the piriformis, and stripped backwards and forwards with the rugine or knife, if requisite. The soft parts are well retracted by the assistant, so as thoroughly to expose the interior of the joint. The head of the femur is dislocated through the opening in the capsule, the ligamentum teres being cut through if necessary.

(*c*) *Removal of diseased parts.*—The neck of the femur is sawn through beyond the limits of the diseased tissue, any sequestrum which may be present removed, and then all thickened or pulpy synovial membrane taken away by dissection or scraping with a sharp spoon. The interior of the joint is flushed out with lotion, and an examination of the acetabulum made. If the disease has involved this part of the joint all affected portions are scraped away.

(*d*) *Closure of external wound.*—The interior of the joint is again washed out, a drainage tube is passed down into the bottom of the cavity, and the external incision closed by the insertion of sutures in the usual manner.

Dressings are applied, and the patient placed on a splint. In the case of a child a double Thomas's hip-splint is the best; for an adult a Thomas's knee-splint with a Sinclair extension.

After-treatment.—The patient must be kept at rest for five or six weeks, and then he can be allowed to get about, a calliper splint being substituted for the other one. It will be necessary, however, for the splint to be worn for nine or twelve months. If the splint is left off too early the ligaments in the region of the hip become elongated and the functions of the limb considerably impaired.

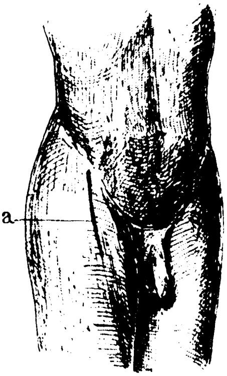

FIG. 467.—Excision of hip-joint through an anterior incision.

a. Position of incision.

Excision of the hip-joint through an anterior incision.—*Position.*—The patient is placed in the dorsal position on the operation table, with the affected hip near the edge. The surgeon stands on the outside of the affected joint, and his assistant on the opposite side.

Operation—An incision 3 to 4 inches in length is made on the antero-lateral aspect of the thigh, commencing above about ½ inch below the anterior superior spine of the ilium, and extending distally and slightly medially (Fig. 467). This incision divides skin and fasciæ, and then by dissection the interval between the rectus femoris and sartorius on the medial side, and the tensor fasciæ latæ and glutæus medius and glutæus minimus on the lateral side, is opened up, and the surface of the capsule of the articulation exposed. The capsule is then incised, and the interior of the joint opened. Often one or more abscess cavities are met with, in which case their interior is thoroughly irrigated before proceeding further. When the joint cavity has been opened it is irrigated, and the diseased portion of the femur removed by sawing through the bone *in situ* beyond the limits of the disease. Any other diseased parts of the joint are removed, as in the previous operation ; and, after washing away all traces of blood, etc, by irrigation, a drainage tube is introduced and the external wound closed. In tuberculous cases it is advisable in many cases to fill the interior of the wound and remains of joint cavity with a sterilised emulsion of iodoform.

The further treatment of the case is similar to that after excision through a postero-lateral incision.

The disadvantages of this operation are the difficulty in obtaining satisfactory drainage, and the limited exposure of the joint during the performance of the operation.

Excision of knee-joint.—The articular surfaces of three bones enter into the formation of the knee-joint. These are the distal extremity of the femur, the posterior aspect of the patella, and the upper end of the tibia. In performing a complete excision all these surfaces are removed.

The object of the surgeon after excision of the knee-joint is to obtain firm bony ankylosis of the tibia and the femur. The operation is usually performed for tuberculous disease. Ankylosis of the joint in a faulty position, some forms of compound dislocation of the joint, and gunshot wounds, may also require this form of treatment.

Partial excision of the knee-joint, or so-called "arthrectomy," is sometimes performed, and in these cases the surgeon aims at producing, if possible, a movable joint. The operation of complete excision will be described first, and the partial operation afterwards.

Excision of the knee-joint (complete).—*Position.*—The patient is placed in the dorsal posture on the operation table, the affected limb being close to the edge, and the distal half of the leg projecting beyond the end of the table. The surgeon stands on the outer side of the affected limb and the assistant opposite to him. A second assistant stands at the end of the table, and holds the limb in the position required.

Operation.—The operation of excision of the knee-joint may be divided into several stages, as follows :—

(*a*) *External incision.*—The limb being held slightly flexed at the knee-joint by an assistant, the positions of the medial and lateral epicondyles of the femur are exactly defined. An incision is made, commencing in the case of the right leg immediately behind the adductor tubercle, then extending in a curved direction distally to the proximal border of the tuberosity of the tibia, and thence upwards to a point immediately behind the prominence of the lateral epicondyle (Fig. 468). This incision divides the skin, superficial fascia, and deep fascia, which is here thickened on account of expansions of the vasti muscles having been inserted into it, and the flap of soft tissues thus marked out is dissected upwards until the superior margin of the patella is reached.

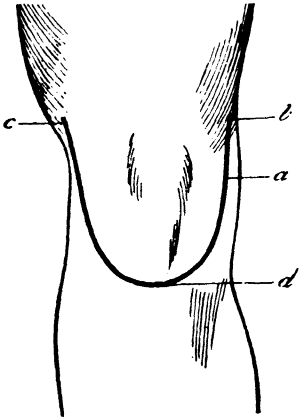

FIG. 468.—Excision of knee-joint. Position and direction of skin incision.

a. Line of skin incision.
b. Position of adductor tubercle.
c. Prominence of lateral epicondyle.
d. Tubercle of tibia.

(*b*) *Opening of the knee-joint and free exposure of articular surfaces, and division of ligaments.*—The aponeurosis of the quadriceps extensor muscle and fibres of the vastus medialis are divided along the proximal border of the patella until the external surface of the synovial membrane is visible. The synovial membrane, including the large pouch which passes upwards underneath the quadriceps, is dissected away from its connections with the deep aspect of the muscles, and then from the anterior and lateral aspects of the femur, until the margin of the articular cartilage is reached. The joint is now opened from above. The incision is extended laterally, and the capsule and the collateral (lateral) ligaments are divided ; the patella is turned downwards, but should not be removed at this stage, as it affords a useful means of steadying the tibia when the bones are being sawn. The bursa and infrapatellar pad of fat which lie between the ligamentum patellæ and the tibia are dissected away, and the head of the tibia cleared anteriorly as far as the margin of the articular surface. The assistant flexes the knee, so as to expose more fully the interior of the joint. The surgeon detaches the cruciate ligaments from their attachments to the tibia and femur, and removes them together with the menisci (semi-lunar cartilages). The limb is still further flexed, and the posterior and lateral aspects of the femur and the tibia cleared for a short distance by a series of small strokes with the knife. The bones are now ready for section.

(*c*) *Section of the bones.*—The knee-joint is bent at a right angle, the sole of the foot resting on the table; the posterior aspect of the condyles of the femur is supported on the proximal end of the tibia, and the limb is held firmly in this position by an assistant. The soft parts are retracted, and the section of the femur is made in an antero-posterior direction. Care must be taken that the saw is held in such a position that the cut surface corresponds to the plane of the articular surface. An ordinary amputation saw with movable back is the most convenient to employ in most cases, but a Butcher's saw (Fig. 469) is required when one of the bones is to be specially shaped to fit the other. Not more than 1 inch of the distal end of the femur should be removed, otherwise there is danger of injury to the epiphyseal cartilage, an accident which might be followed by considerable shortening of the limb if the operation were being performed on a young individual (Fig. 430).

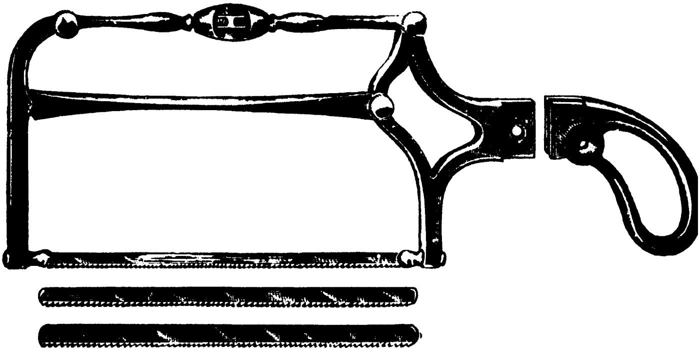

FIG 469.—Excision of the knee-joint. Saw for section of bones.

The proximal end of the tibia is next made to project beyond the femur, the leg being held in a vertical position with the foot still resting on the table, and the saw-cut is made in a horizontal plane from before backwards.

The two sawn surfaces of bone must be in a plane corresponding to that of the articular surfaces which are removed, otherwise when the bones are brought into apposition the limb will be found to be bent at an angle.

The patella with its attached ligamentum patellæ and portions of the capsule and synovial membrane are taken away, the ligamentum patellæ being cut through at its attachment to the tubercle of the tibia.

The posterior portion of the joint is now examined, and any remaining portions of synovial membrane or thickened bursæ removed. The prolongation of the synovial membrane of the knee-joint around the tendon of the popliteus muscle should be examined, and in nearly all cases it will be advisable to dissect it out, since it invariably communicates with the cavity of the knee-joint. Any other bursæ which are thickened or communicate with the cavity of the knee-joint should be treated in a similar manner.

(*d*) *Co-aptation of the ends of the femur and tibia, and application of a suitable splint.*—The best splints after excision of the knee are (i) the one represented in Fig. 471 ; (ii) Gant's back splint, with a long interrupted Liston applied to the outer side of the limb ; (iii) a Macintyre's metal knee splint. One of these splints is applied, fixed in a position by careful bandaging, and the extremities of the bones brought into exact apposition.

Various methods of pegging or wiring the ends of the bones together have been employed, but they are not usually necessary. When, however, the extremities of the bones cannot be maintained in good apposition, two pins of steel or phosphor bronze are used to fix the bones together. They should be driven in from below the lower angles of the wound through the head of the tibia into the distal end of the femur, in an oblique direction, the medial one upwards and laterally and the lateral upwards and medially. The lower extremities are allowed to project, and at the expiration of ten to fourteen days they are removed.

It is advisable in most cases to fix the limb on the splint before closing the external wound with sutures.

(*e*) *Closure of external wound.*—The margins of the incision through the skin and fasciæ are brought into exact apposition, and fixed by the insertion of a number of interrupted sutures.

The medial and lateral angles of the wound should be left slightly open, and a small drainage tube introduced so as to allow of the escape of any exudations which may take place. This is removed at the expiration of twenty-four to thirty hours, and the suture which has been left loose tightened.

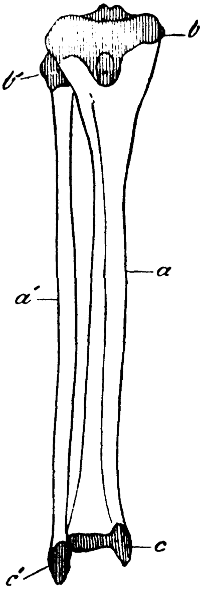

FIG. 470.—Excision of knee-joint. Tibia and fibula, showing the parts of the bones derived from the several centres of ossification. (The femur is illustrated in Fig. 430, p. 635.)

a. Diaphysis of tibia.
b. Proximal epiphysis of tibia.
c. Distal epiphysis of tibia.
a'. Diaphysis of fibula.
b'. Proximal epiphysis of fibula.
c'. Distal epiphysis of fibula.

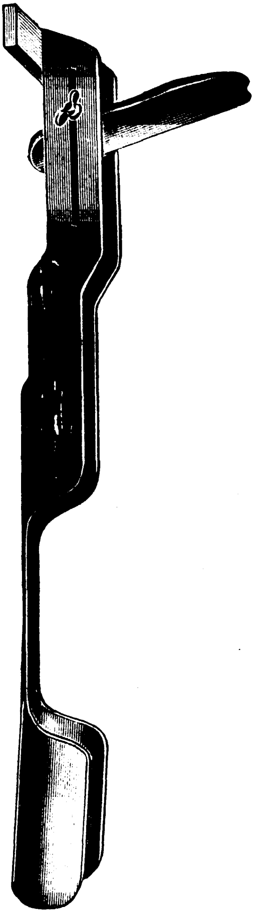

FIG. 471.—Excision of knee. Splint for use after operation.

Dressings are then applied. It is not usually necessary to introduce a drainage tube if the angles of the wound are left open as above.

After-treatment.—The limb is kept at rest on the splint for about six weeks, until firm union has occurred.

At the end of about three months, in favourable cases, the patient may be allowed to use the limb in which the knee-joint has been excised.

Excision of the knee-joint (partial).—This operation has been called "arthrectomy," or "erasion" of the joint. The best term is, I think, *partial excision*; but if it be preferred, *erasion* may be used.

Indications.—The operation is performed in early cases of tuberculous disease in which only a part of the anatomical elements of the joint are involved in the pathological process. It is recommended that it should be done when the synovial membrane alone is involved. Palliative and non-operative methods are now usually practised in the treatment of early tubercular diseases of joints.

Operation.—A transversely curved incision is made across the front of the knee, as in excision. The ligamentum patellæ is cut through at the lower part of the incision, and the joint cavity opened from below. The ligamentum patellæ, the patella, and the capsule of the joint are lifted upwards, and the interior of the joint exposed. Another method of exposing the interior of the joint is to make a vertical incision through the patella, the ligamentum patellæ, and the quadriceps extensor, and to widely retract the divided structures. All thickened or pulpy synovial membrane is then dissected away, or removed by scraping with a Volkmann's spoon, any infiltrated ligaments or menisci are cut away, and if the articular ends of the bones are affected the involved areas are thoroughly scraped, so as to get away all diseased tissue.

When the joint has been freed from all traces of affected tissue the interior is well irrigated with normal saline or a solution. The ligamentum patellæ and the margins of the incision in the capsule are united by the insertion of a series of silk sutures. Next, the external wound is closed in the usual manner, and the limb put up in a suitable splint.

When complete healing has taken place passive movements are commenced, and an attempt made to get a movable joint.

Kocher recommended that the first incision should be similar to that recommended for "complete excision," and that, after the flap of skin and fasciæ has been dissected up, the knee-joint should be opened on each side of the patella, and all necessary manipulations carried out through this incision. The advantage of this method is that the ligamentum patellæ is not interfered with, and when healing has taken place a much stronger articulation is left. He claimed also that a better exposure of the interior of the joint is obtained by this method. Kocher's arguments appear to have a considerable weight, and if a partial excision of the knee-joint is to be attempted it is probable that this operation will lead to a satisfactory result in well-selected cases.

The results which have been obtained from this operation have not been very satisfactory. Usually fibrous ankylosis follows, when there is little movement and the joint is permanently weak.

Excision of the ankle-joint.—The bones which enter into the formation of the ankle-joint are the distal articular extremities of the tibia and fibula, and the proximal and lateral articular surfaces of the talus (artragalus, O.T.). The ligaments which hold these articular surfaces together are anterior, posterior, talo-fibular (with three fasciculi), and deltoid. There is a single synovial membrane.

Owing to the complicated nature of the joint, excision has not been followed by such good results as has been the case in other joints.

Indications.—The chief clinical conditions which may necessitate an excision of the ankle-joint are—

(*a*) Tuberculous disease, either originating in the joint or extending to it from one of the adjacent bones.

(*b*) Some cases of compound dislocation of the joint, with fracture of one or more of the bones.

(*c*) Some forms of suppuration of the joint.

(*d*) Some cases of talipes.

Many varieties of operation have been carried out by different surgeons in excising the ankle-joint. The best operation appears to be that which has been recommended by Kocher and Reverdin. In this procedure the joint is excised through a single incision situated on the anterior and lateral aspects of the foot.

Position.—The patient is placed in the dorsal position on the operation table, with the affected foot lying on its inner side and supported by a sandbag covered with a sterilised towel. The foot should be near the extremity of the table. The operator stands on the outer side of the affected foot, the chief assistant stands opposite to him on the sound side, and a second assistant at the end of the table. The duty of the second assistant is to hold the foot and manipulate it as required by the surgeon.

Operation.—An incision is made across the dorsal and lateral aspects of the foot (Fig. 472). It commences at a point ½ inch below the centre of the ankle-joint, extends laterally and backwards to the distal margin of the lateral malleolus, and then proximally and somewhat medially to the fibular margin of the tendo calcaneus. The incision is usually from 3 to 3½ inches in length, and is curved in outline, the concavity looking proximally and towards the tibial margin of the limb.

The skin and fasciæ are divided, the lateral portion of the superficial peroneal nerve sought for in the medial part of the wound, and when found retracted to the medial side, and the small nerve and vein in the lateral part behind the lateral malleolus. When the deep fasciæ and the fibres of the transverse ligament of the leg have been cut through, the tendons of the extensor muscles will be exposed in the anterior part of the wound, and those of the peronæi in the posterior part.

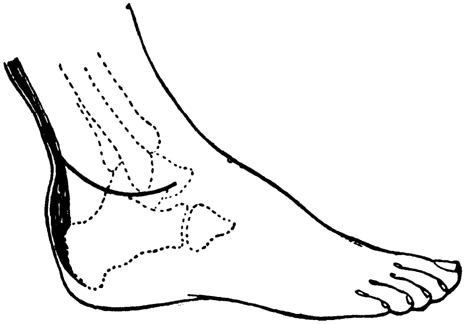

FIG. 472.—Excision of ankle-joint. Position of skin incision.

With a rugine or periosteal elevator the deep fascial processes of the cruciate ligament, and the peronæi tendons with their sheath, are separated from the lateral aspect of the calcaneus and peeled backwards. In very inveterate cases of club-foot it may be necessary to cut through these tendons, this section being repaired by suture at the end of the operation. Next, the extensor tendons at the anterior angle of the incision, the processes of the transverse ligament of the leg, and the anterior ligament of the ankle-joint, are separated with the rugine, and retracted towards the tibial side. The talo fibular and the posterior ligaments are then treated in a similar manner, by detaching them from their bony attachments. When these structures have been separated, the joint will be opened on its posterior, medial, and anterior aspects. The deltoid ligament is left undisturbed.

The foot is now forcibly adducted towards the tibial side, and completely dislocated medially until the plantar surface lies in contact with the skin on the medial side of the leg. The trochlear surface of the talus (artragalus, O.T.) and the distal extremities of the tibia and fibula appear in the wound.

A saw of suitable shape is taken, and the diseased portions of the exposed bones removed. All thickened or pulpy synovial membrane and thickened tendon sheaths are removed by dissection. If the talus is extensively involved in the disease, or if the synovial membrane of the talo-navicular joint is affected, it will be necessary to remove the entire talus along with all other infiltrated and diseased tissues.

All bleeding is now arrested, and the foot brought into its original position. If the peroneal tendons have been divided the cut ends are sutured together. The ligaments on the lateral aspect of the joint are united with sutures, if possible, and the external wound closed in the usual manner.

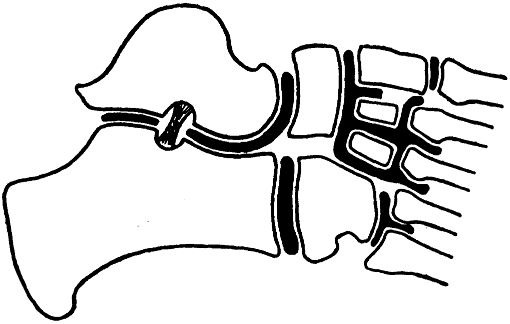

FIG. 473.—Synovial membranes of tarsus and metatarsus.

Dressings are applied, and the limb fixed on a back splint with a foot-piece, side splints being used if considered requisite. The limb must be kept on the splint until complete healing and union of the divided tissues has taken place.

Excision of the metatarso-phalangeal and interphalangeal joints.—Excision of these joints is performed through a single incision, or through double lateral incisions, placed a little nearer the dorsal than the plantar aspect of the sole (Fig. 474). The individual operations differ in no essential respects from the operations on the corresponding digits of the upper extremity.

Excision of head of metatarsal bone of great toe.—Excision of the head of the metatarsal bone of the great toe is frequently performed on account of hallux valgus.

Operation.—An incision 2 to 2½ inches long is made over the antero-medial aspect of the joint in the direction of the long axis of the digit, the soft tissues divided and the joint opened (Fig. 474, *a*). The ligaments forming the capsule of the articulation are separated from their attachments to the bone with a rugine, and the head of the bone made to protrude. Next, this is removed either with a saw or bone forceps, the section being made in such a manner that the sawn or cut surface fits the base of the phalanx when the digit is forcibly straightened. The anterior and posterior margins of the sawn surface are trimmed with bone forceps so as to give rounded margins. Any bunions which may be present are dissected out, overlying callosities of skin excised, and the margins of the incision united by sutures.

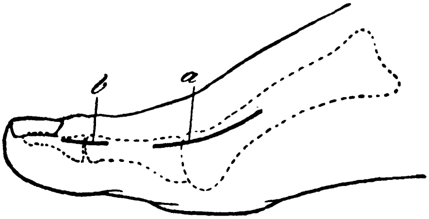

FIG. 474.—Excision of metatarso-phalangeal and interphalangeal joints of great toe.

a. Position of skin incision for metatarso-phalangeal joint.
b. Position of skin incision for interphalangeal joint.

Passive movements should be commenced after seven to ten days, and kept up until a fibrous joint is established.

Excision of the temporo-mandibular joint.—The temporo-mandibular joint is formed by the glenoid cavity of the temporal bone and the condyle of the lower jaw.

Important anatomical structures lie in very close relation to the joint. The auriculo-temporal nerve and the superficial temporal artery lie posterior and external, the internal maxillary artery is below and internal, whilst the glenoid lobe of the parotid gland is situated immediately behind the condyle. The facial nerve lies in the parotid gland at a lower level.

Indications.—Excision of the temporo-mandibular articulation may be necessary in tuberculosis of the joint, in some forms of osteoarthritis, and in bony ankylosis from any cause, such as gonorrhœal arthritis.

Position.—The patient is placed in the dorsal posture, with the head turned towards the sound side, and supported by a pillow or sandbag. The surgeon stands on the affected side of the head, and his assistant directly opposite to him.

Operation.—An incision about 1½ inches in length is made along the inferior margin of the posterior part of the zygomatic arch, the skin being pulled upwards with the fingers of the left hand before the incision is made.

The incision commences immediately in front of the anterior margin of the external auditory meatus, and extends forwards towards the prominence of the zygomatic bone (Fig. 475). The skin, superficial fascia, and the deep fascia are divided, the auriculo-temporal nerve and the superficial temporal vessels being avoided in the posterior angle of the incision, and the temporal branch of the facial nerve in the anterior. In the anterior part of the incision the posterior margin of the masseter muscle will be exposed, and posteriorly the upper part of the parotid salivary gland. The fibres of the masseter are retracted forwards (some of them being divided if requisite), and the parotid gland backwards. The external portion of the capsule of the joint is divided, and the cavity opened. The neck of the lower jaw is next freed from the soft tissues, and with a fine saw it is divided from before backwards. The condyle is then seized with a pair of lion forceps, and forcibly pulled outwards. As this is being done the undivided parts of the capsule are cut through with the scalpel, and the external pterygoid muscle is detached from the anterior and internal aspect of the neck immediately below the articular surface.

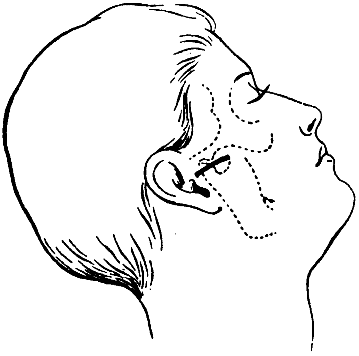

FIG. 475.—Excision of temporo-maxiliary articulation. Position of external incision.

The head of the bone can now be removed. The interior of the joint is examined, and any diseased tissue removed.

All bleeding is then arrested, and the external wound closed by the insertion of sutures.

Excision of the temporo-mandibular articulation is in most instances a partial excision, the condyle being the only portion of bone which is taken away.

CHAPTER XXIX

AMPUTATIONS AND DISARTICULATIONS

By the terms amputation or disarticulation is understood the detachment and removal of a limb or part of a limb from the body.

The plane of section of the limb may pass either through a bone or bones, or through a joint; in the former case the operation is usually designated an amputation, whilst to the latter the term disarticulation is often applied.

The term amputation is also applied by some surgeons to removal of the whole or part of the penis, the tongue, mammary gland, external auricle, and other dependent organs. It is better, however (with the possible exception of the penis and breast), to restrict the term to removal by operation of a part, or the whole of one of the upper or lower extremities.

Amputation or disarticulation of a limb should only be recommended in those cases in which it is impossible to save the limb or part of a limb by conservative and restorative measures, and at the same time leave a member which is of use to the patient. Aseptic and antiseptic surgery has, except in the case of patients suffering from malignant disease, so enlarged the field of conservative surgery that amputations and disarticulations are much less frequently performed than was previously the case; and now it is considered a more creditable surgical performance to be able to save a diseased or injured limb than to remove it by an operation. When, however, malignant disease of a limb, either of the bone or soft parts, is under consideration, it must be remembered that conservative surgery does not offer the same advantages as regards saving the limb; but, on the other hand, it enables us with greater safety to remove the limb some distance above the seat of disease, and also to take away any lymph glands or groups of lymph glands which receive lymph vessels from the affected area. The mortality from operations involving removal of a limb or part of a limb, on account of malignant disease, has been considerably reduced; and, owing to the more complete character of the actual procedure, in taking away all possibly diseased or infected areas, the patients are less liable to recurrence of the affection. It will be seen from these considerations that it is often a question of great difficulty to determine when to adopt conservative measures, and when and where to practise amputation or disarticulation.

Many injuries, which on a primary investigation appear to warrant amputation, when properly and scientifically treated by strict aseptic or antiseptic surgical methods, frequently heal; and, conversely, a certain number of small and slight injuries, which are treated by careless and inefficient aseptic or antiseptic methods, ultimately, owing to the development of severe complications, cause loss of the whole or part of a limb, or even terminate fatally. Also, antiseptic surgery enables us to treat, by conservative methods, many of those complications which follow mechanical injuries to limbs, and which in former days were invariably regarded as necessitating amputation or disarticulation. It is of the very greatest importance, in the surgical treatment of injuries of the hands and fingers, to make every attempt to save as much of the limb as possible. If only a portion of one digit in an injured hand can be saved, this should be done, since part of one finger or a thumb which is movable is of far greater use to the patient than the best artificial hand.

INDICATIONS FOR AMPUTATION

A careful and scientific consideration of the "indications for amputation" involves a detailed and exact knowledge, in each individual case, of the character and extent of the pathological condition, disease, or injury which causes the question of the possible performance of an amputation to be brought forward. Thus it often happens, in order to justify a decision to amputate a limb or portion of a limb, that more than one surgical opinion is invoked. Whenever there is a doubt as to what line of treatment—conservative or amputation—ought to be recommended, it will be found advisable usually to allow the benefit of the doubt to incline towards conservative methods.

The following summary comprises most of the clinical conditions which may necessitate the performance of an amputation or disarticulation:—

(*a*) *Compound fractures of one or more bones of a limb, associated with extensive solutions of continuity in the main arterial, venous, and nerve trunks.*—Such injuries, when not treated by amputation, in almost all cases are followed at an early stage by the appearance of gangrene of that portion of the limb which lies at and beyond the seat of injury. When this occurs an amputation is rendered imperative, and, when performed, is much more likely to give rise to septic complications which may prove fatal. On this account it is strongly recommended, when it has been decided that a limb ought to be removed on account of the severity and extent of the injuries, that the operation should be carried out as soon as possible after the damage has been received. When there is much shock after the reception of an injury necessitating an amputation, the patient should be allowed to recover from this before commencing the amputation.

(*b*) *Extensive injuries to the soft parts of a limb.*—Certain cases of extensive injury to the skin and the soft tissues of a limb, such as when the skin has been separated for the entire circumference of a segment of a limb, and the underlying fascial and muscular layers, together with some of the main arterial and nervous trunks, have been severely lacerated, can only be successfully treated by amputation. Some surgeons recommend, when dealing with conditions of this kind, that sufficient time should be allowed to elapse in order to determine where the line of demarcation will form, and, when this has become apparent, to carry out an amputation on the proximal side of this line of demarcation. This, in my opinion, is a dangerous method to adopt, since, owing to the impossibility of making the injured tissues aseptic, putrefactive and septic processes establish themselves, and, when an operation is performed, especially when through the proximal portions of one of the extremities, they cause the death of a considerable number of patients, by extension of these septic processes to the field of operation. A class of injury of this kind which is occasionally met with is caused when a patient has been caught between a moving subject, such as a train, and a solid body, such as a station platform. I have seen a number of patients who have slipped between a station platform and a moving train, and in whom the skin and underlying fascial tissues have been completely separated from the deeper structures, and the blood vessels torn and lacerated so extensively, that it was necessary at once to perform an amputation. Often in these cases the injury to the superficial aspect of the skin has been insignificant.

(*c*) *Prolonged suppuration.* — Some cases of suppurative diseases of bone, such as septic osteomyelitis, may necessitate amputation when the septic process involves the bone and adjacent joints, and also when the fascial and intermuscular planes of the affected limbs are infiltrated by the products of the pathological process. This is especially the case when the septic condition is acute and the onset of pyæmia is threatened, or when chronic suppuration and amyloid disease has become established. Amputation, however, in cases of this kind, should not be recommended until it is clear that conservative measures, such as free incisions, establishment of free drainage, and the application of antiseptic solutions, have completely failed to arrest the progress of the disease. Tuberculous disease of a bone, owing to its intractability to local methods of treatment and its tendency to spread to adjacent tissues, occasionally requires treatment by amputation or disarticulation. The onset of amyloid disease is in a number of cases the determining point in deciding upon amputation.

(*d*) *Gangrene of a limb or portion of a limb from any cause.*—Gangrene in connection with a limb or part of a limb may be due to a variety of causes. Thus, in one class of patients, it is the direct or indirect result of the reception of an injury, in which cases it is often designated as " traumatic gangrene " ; in another class it is of the nature of " hospital gangrene," owing to infection of the damaged tissues by an anaerobic organism ; in a third class it occurs in association with diabetes ; in others again, it is due to thrombosis of the large blood vessels which supply the affected limb ; whilst in others, senility and atheroma of the blood vessels appear to be the cause.

Whatever the cause of gangrene, the dead and useless tissues must be removed sooner or later. When the gangrene is of traumatic origin, and at the same time the tissues of the affected limb are the seat of septic processes, which are sufficiently severe to render possible or probable a fatal result, amputation should be performed as soon as possible. This is especially necessary when the gangrene is of the variety known as " acute traumatic." When the gangrenous condition follows an injury, and there is no evidence of septic infection of the damaged tissues or of the adjacent portions of the affected limb, it is usually advisable to wait until the line of demarcation between the dead and living tissues can be determined, since this forms a definite indication as to the exact site where the amputation ought to be performed.

Before coming to a definite decision as to the level at which an amputation should be performed, it is necessary first to select sound tissues through which to make the incisions ; and secondly, to ascertain that the main arterial trunks are permeable to the blood stream at the site where the operation is proposed to be carried out. This can be ascertained usually by paying attention to the temperature of the limb, state of sensibility of the skin, and the presence or absence of arterial pulsation in the tissues of the limb at the level of the plane of proposed section. When, owing to the development of gangrene, it is considered necessary to perform an amputation in a patient who is the subject of diabetes, atheroma of the blood vessels, or Raynaud's disease, it will often be found advisable to perform the amputation a considerable distance above the gangrenous area, on account of the defective circulation in the tissues immediately proximal to the diseased parts. Thus, in gangrene of the foot from one of these causes, it may be advisable to remove the limb by an amputation above the knee-joint, through the lower third of the thigh; although usually the " seat of election " will be found a suitable site.

(*e*) *Chronic ulcers of the leg.*—Chronic ulcers of the leg—non-malignant in character—when they involve more than two-thirds of the circumference of the limb, usually necessitate amputation. In doubtful cases it is strongly recommended that an attempt be made to render the diseased areas aseptic by the use of fomentations and antiseptic applications, and when this has been successfully done, to try, by plastic procedures and skin grafting, to cover the ulcerated areas with comparatively sound skin. If, however, the entire circumference of a limb is involved in an ulcerative process, then amputation should always be recommended, since plastic operations and skin grafting do not give rise to satisfactory results. Before coming to a definite decision in some of the cases of this class, it is necessary to take into consideration the position in life and the occupation of the patient, since, in people of means who have of necessity no physical labour to perform, it is often possible to preserve a limb in such a manner that it is quite a useful one; whilst if a patient's occupation necessitates much walking, and other physical exercise, then it is preferable that it should be removed and a suitable artificial one substituted.

(*f*) *Certain cases of congenitally deformed and useless limbs, old paralytic limbs, supernumerary digits, and atrophied limbs, which are useless to the patient, are a source of inconvenience, and cannot be improved by orthopædic measures.*—Whenever a limb is quite useless in the patient's economy, from one of the above enumerated causes, is a source of inconvenience to him, and there is no valid objection to the performance of a surgical operation, then the surgeon ought to recommend that an amputation of the useless member should be practised.

(*g*) *Sarcoma.*—Sarcoma of one of the bones of a limb, in which the diagnosis is certain, is, in the majority of cases, best treated by amputation of the limb on the proximal side of the disease, and well above any infiltrated tissues. If the tumour be of the myeloid variety, local excision should first be practised, whilst a similar operation may be carried out in some of the slow-growing and less malignant forms of fibro-sarcoma. Very careful observation, however, should be made of the patient for some time after the operation has been performed, since some forms of sarcoma, which at first appear to be not very malignant, quickly recur and acquire more pronounced malignant characters. When a recurrence has taken place locally, amputation of the affected limb should at once be advised. The longer the time which is allowed to elapse before amputation the greater are the probabilities that secondary deposits will have commenced to form, either in the lymph glands, or in one or other of the internal viscera. Sarcoma of the periosteum, or of the medulla, when not of the myeloid variety, ought, as a general rule, to be treated by amputation of the limb through or above the next joint on the proximal side of the affected bone. When the tumour is a myeloma, if amputation is considered necessary it should be performed above the level of the tumour, and *through* the affected bone. An exception may be made when the growth is located in the distal extremity of the femur. Then the level of the section of the bone is the distal part of the proximal third. This is rendered advisable on account of the much greater mortality which follows disarticulation at the hip-joint, than when amputation is performed through the upper third of the femur, and also because it has been found, by clinical experience, that the percentage of recurrences is about the same whether the operation is through the hip-joint or through the upper part of the shaft of the femur. Sarcomata of the muscles or fasciæ of a limb usually justify the performance of an amputation at as early a period as possible, on account of their great proneness to recur if they are removed locally. To this there are certain exceptions, and each case must be carefully considered in all respects and decided on its individual characteristics.

(*h*) *Carcinoma.*—Carcinomatous affections of the skin of the extremities often necessitate amputation ; but the extent of the disease, as regards the amount of skin involved and the subjacent tissues invaded, must guide the surgeon in coming to a decision. It will usually be found advisable to remove the lymph glands which receive the lymph vessels from the affected areas at the time of operation, in order to free the patient as far as possible from the danger of a recurrence. Secondary carcinoma, when it involves the bones or tissues of the extremities, does not call for amputation, on account of the impossibility of freeing the patient from all the manifestations and foci of the disease.

When an amputation or a disarticulation is performed immediately after the reception of an injury, and on account of the effects of the injury, it is usually designated a "primary amputation or disarticulation." "Secondary amputation" is the term which is applied to an amputation when carried out some time after the reception of an injury, and necessitated by septic infection of the injured tissues, or the occurrence of gangrene. At the present time, secondary amputations are performed much less frequently than formerly, on account of the better results which have followed the antiseptic and aseptic treatment of injuries of the extremities.

POINTS TO WHICH PARTICULAR ATTENTION SHOULD BE PAID IN AMPUTATIONS

(*a*) *Determination of the site at which the limb, or portion of limb, is to be removed.*—It has often been stated by surgical authorities that, as a general rule, the value of a stump is greater in proportion to its length, and the farther from the trunk the limb is removed the less is the risk to life from the operation, and hence that as much as possible of a limb should always be preserved. This statement requires considerable modification, since it ought to be the object of every surgeon who undertakes an amputation, to provide the most useful and painless stump possible, in order to enable the patient to use it without unnecessary pain and trouble. This, in addition, allows the surgical instrument-maker to fit a well-designed artificial substitute for the part which has been removed. It has been found by experience that a "conical stump" is the best for practical purposes, since it permits an artificial limb to be fitted in such a way that little or no pain results from wearing it. On this account it is strongly advised that all amputations above the ankle and wrist-joints, especially the former, should be so designed and carried out as to provide the patient with a conical-shaped stump. The surgeon, however, in these endeavours to provide a useful and painless stump, must not leave tissues behind which are suspected, and which may probably be the seat of a recurrence of the disease. When coming to a decision concerning the seat of an amputation on the hand, in the region of the wrist-joint, it is necessary, in addition to providing a useful stump, to have regard to the physical appearance of the part. This is a point which especially requires careful consideration in ladies, and in persons whose position in life does not necessitate the retention of the most useful hand possible. Concerning the argument that the farther the plane of section of the limb from the trunk the less the risk to life, it can be definitely asserted that, since improved aseptic and antiseptic treatment of operation wounds has been adopted, this supposed danger is really non-existent. The collective records of recent operations of this kind abundantly demonstrate this conclusion.

(*b*) *The skin.*—Sufficient skin must, if possible, be retained to form a complete covering for the stump, without causing undue tension. The skin-flaps should be so arranged and fashioned that the resulting scar shall not lie in a situation where it may be exposed to excessive or frequent pressure. In the arm and forearm the scar should be situated over the end of the stump, as this part is not subjected to pressure by an artificial limb. The contrary is the case in the lower limb ; the patient walks on the end of his stump. Attention should also be paid, when deciding upon the size and shape of the flaps, to ensure that they shall have an adequate blood supply. When making skin-flaps, therefore, the essential rules to follow are—(*a*) that the flaps shall be of unequal length ; (*b*) that the bases shall have a wide attachment and an adequate blood supply ; (*c*) that as regards dimensions of flaps, the breadth of each flap shall be equal to half the circumference of the limb at the base of the flaps ; and the combined length of the two flaps shall be one and a half times the diameter of the limb at the level of the plane of section.

In exceptional cases the rule as regards providing a complete skin covering may be relaxed, since much may be done at a later period, by plastic operations, in restoring or completing the cutaneous covering of the terminal part of a limb.

(*c*) *The covering of the stump.*—The flaps should be so fashioned that plenty of fasciæ and muscle is left to form a good covering for the bone, and also to ensure an adequate blood supply to the flaps themselves. When the muscles of a limb are divided in an amputation, they retract towards the proximal end of the stump, and on this account due allowance must always be made for this tendency to retraction, otherwise it will happen that a surgeon is unable to cover the end of the limb with a suitable covering, and in order to effect this satisfactorily it becomes necessary to remove another segment of the bone and the adjacent tissues. When the incision through the soft parts has extended to the bone the periosteum should be cut through in a circular manner, and then dissected upwards for ½ inch or more, according to the diameter of the bone at the level of section, so that, after the bone has been sawn through, the separated periosteum is sufficiently long to enable the surgeon to cover the cut surface of bone with it. Usually, after the periosteum has been separated in this manner, it is fixed over the cut end of the bone by the insertion of a few sutures. This method of dealing with the periosteum tends to prevent undue retraction of the muscles, provides a sufficient amount of soft tissues to cover the end of the bone, and assists in the formation of a conical stump.

After the periosteum has been fixed over the cut end of the bone, the divided extremities of the muscle should also be fixed to the deep fascial layers, and also to one another, by the insertion of a number of buried sutures, which in the majority of instances should be of strong catgut. This method of muscle-suturing diminishes the *dead space* of the wound in which fluids can collect, and hence the amount of secretion or exudation from its surface. It also ensures temporary fixation of the cut ends of muscle, which enables them to unite to the deep fascial layers, shortens the time occupied by the healing process, and helps in assuring a useful and painless stump. Fixation of the cut ends of muscle in this fashion also lessens the amount and severity of the post-operative pain, which is essentially due to irregular muscular contractions and twitchings.

In the case of a disarticulation, or amputation through a joint, if the nature of the case will permit, the capsular ligament is divided at the lower part of the articulation, and then brought over the end of the bone in a manner similar to that recommended above in the case of the periosteum.

(*d*) *The nerves.*—When dividing the soft tissues an attempt should be made not to cut the nerves in such a manner that their extremities shall be so situated that they are liable to undue or frequent pressure.

The most frequent cause of painful stumps is either the development of a " neuroma or bulbous enlargement " of the divided end of one or more of the nerve trunks, or the involvement of one or more of these cut nerve-ends in the scar tissue of the stump. This unpleasant after-complication of an amputation can be avoided generally by dissecting out from the nerve sheath and removing about 1½ inches or even more of each of the main nerve trunks on the proximal side.

(*e*) *The control and arrest of hæmorrhage and the prevention of unnecessary shock.*—At the time of operation the portion of the limb which it is desired to remove should be rendered "bloodless," either by the application of a rubber bandage, as in Esmarch's method, or by raising the limb for some minutes, and with the hands manipulating it, so that the greater part of the blood within it is forced towards the trunk. When the tissues have been freed from blood by one of these methods, an elastic constrictor or tourniquet is placed around the proximal part of the limb in such a manner that it is not liable to slip during the operation, when the muscles have been divided and retracted. A piece of lint is placed between the rubber constrictor and the skin. The tourniquet is applied sufficiently tightly to arrest the circulation of the blood in the large vessels. This method of operation minimises as much as possible loss of blood by the patient, and hence also diminishes the risk of the occurrence of severe shock.

In order to minimise shock in large amputations, some surgeons recommend intravenous injections of novocain into the nerve trunks proximal to the site of amputation. The value of this method of treatment is somewhat uncertain.

METHODS OF AMPUTATION AND DISARTICULATION

A considerable number of methods have been and still are made use of in the performance of amputations and disarticulations. A description of the most important ones will be given, and indications pointed out as to which are the best to adopt in individual cases and in different parts of the limbs.

1. The flap method.—In the performance of an amputation by this method, one or more flaps are fashioned from the soft tissues of the limb. These flaps may consist either of skin and fasciæ alone, or of skin, fasciæ, and muscle. In the latter case the skin should always be cut longer than the muscles. It is better, in the majority of instances, that an amputation flap should contain muscle at its base, and not consist throughout of skin and fasciæ alone.

Varieties of the flap method.—(*a*) *Single flap.*—The single flap may consist of either skin and fascia, or of skin, fascia, and muscle, and may be formed from the tissues on any aspect of the limb. Its width should be equal to half the circumference of the limb at the level at which the bone is to be sawn, and the length one and a half times the diameter at the same level.

(*b*) *Two flaps.*—When two flaps are formed they may either be of equal length, or one may be longer than the other. It is generally preferable that the flaps should be of unequal length, so that the resulting scar may not be situated over the extremity of the stump. The flaps may either be antero-posterior or lateral.

When the flaps have square-cut extremities they are called "rectangular" flaps; when the angles are rounded off, "U-shaped." The latter (U-shaped flaps) will generally be found more convenient, and will give a better-shaped stump than rectangular ones.

The best method for the formation of flaps in amputations is that which comprises the fashioning of two cutaneo-fascial flaps, one longer than the other, each U-shaped, and consisting of skin, superficial fascia, and subcutaneous tissues, and the deep fascia. When the two flaps are of unequal length the line of union and subsequent scar are away from the end of the bone, and consequently in such a position as to conduce to a useful and painless stump.

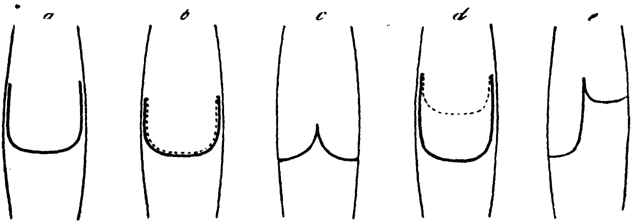

FIG. 476.—Forms of amputation flaps.

a. Single flap.
b. Equal antero-posterior flaps.
c. Equal lateral flaps.
d. Unequal antero-posterior flaps.
e. Unequal lateral flaps.

2. The circular method.—In this method the tissues of the limb are divided in a circular direction, that is to say, at right angles to the long axis of the limb which is being operated upon. The different tissues, however, are not all divided at the same level, the superficial structures being cut through more distally than the deeper ones. The operation wound, in an amputation performed by the circular method, has the form of a cone, the edge of the base of the cone corresponding to the cut margin of the skin and the apex to the bone (Fig. 477).

Particular care should be taken not to pull down the skin before dividing it, otherwise difficulty may be experienced in covering the end of the amputation stump, without undue tension.

The skin and superficial fascia are first divided, and then retracted, so as to expose the deep fascia at a slightly higher level. Next, the deep fascia is divided in a similar manner, and retracted. The superficial muscles are now cut through and allowed to retract, and then the deep muscles. After this the periosteum is incised and dissected back for a short distance, and finally the bone is sawn through. The periosteum should be separated sufficiently to cover entirely the sawn end of the bone.

When a circular amputation is being performed, where there are few soft tissues, the skin and superficial and deep fascia are turned backwards in the form of a "cuff," so as to give more cutaneous covering for the stump.

One disadvantage of performing an amputation by the circular method is, that the scar is nearly always situated at the extremity of the stump, and is liable to injurious pressure and to form adhesion to the end of the bone.

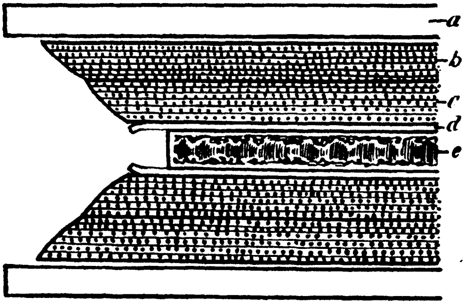

FIG. 477.—Diagrammatic representation of the stump of a limb when a circular amputation has been performed.

a. Skin and superficial fascia.	*c*. Deep muscles.
b. Deep fascia and superficial muscles.	*d*. Periosteum.
	e. Bone.

3. The elliptical or oblique circular method.—The skin incision in this operation has the form of an ellipse, one extremity being nearer the proximal portion of the limb than the other (Fig. 478). The manner of division of the different tissues is exactly similar to that adopted in an ordinary circular amputation.

The elliptical method is a good one, since the resulting scar is situated not over the extremity of the stump, but a short distance proximal to it. A movable cutaneous covering for the stump is thus ensured.

4. The modified circular method.—In the modified circular method of amputation a circular incision is first made through the skin and fascia; then one or two lateral incisions are made, which extend proximally for a short distance. If two lateral incisions are made, we have two short flaps which may be rectangular in shape, or have the corners rounded off. The flaps in all cases are of equal length, and are composed of skin and superficial and deep fascia. The further stages of the operation are similar to those in the circular method (Fig. 479).

5. The modified elliptical or " racket shaped " method.—This form of amputation is a modification of the elliptical method, the incision being prolonged up the limb from the proximal extremity of the ellipse (Fig. 480).

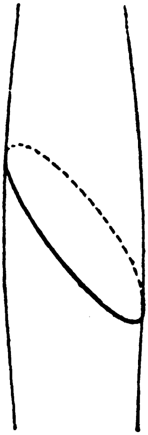

FIG. 478.—Method of making an elliptical or oblique circular incision.

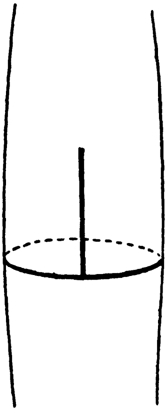

FIG. 479.—Modified circular incision.

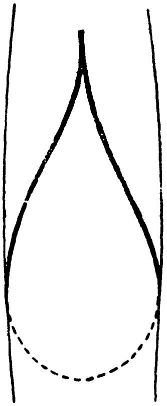

FIG. 480. — Modified elliptical or "racket-shaped" incision.

MODES OF FASHIONING FLAPS

Three distinct modes of fashioning flaps are practised, but in my opinion the one which is first described is that which fulfils all ordinary operative requirements, and ought therefore to be adopted in almost every case.

(*a*) *By cutting from without inwards.*—Nearly all amputation flaps should be made by cutting from without inwards, and never in the converse direction from within outwards. When a flap is fashioned by this method an incision is made through the skin and superficial fascia, marking out the size and shape of the flap. These tissues are retracted for a very short distance, and then the deep fascia is cut through. The flap, thus commenced, is dissected upwards for a variable distance, according to the case which is being operated upon, and then the muscles are cut until the periosteum of the bone is reached. This latter is cut through, either in a circular manner, or a flap is fashioned and separated from its connections with the bone for a sufficient distance, so that, when the section has been made through the bone, this cuff or flap of periosteum will form a complete covering for the end of the bone. For this method of making amputation flaps it is advisable to use a knife with a moderately short and stout blade. Fig. 510 illustrates a knife of suitable form.

(*b*) *By transfixion.*—In this case a knife whose blade is equal in length to at least half the circumference of the limb is used. The first incision transfixes the limb from side to side. Thus, in amputation of the forearm by this method, the knife is entered on one side, passes down to the bone, then across the limb in front of the bones until its point emerges on the opposite side, half-way round the limb. By a sawing movement the tissues are divided in a distal direction for the necessary distance. The edge of the knife is then turned towards the surface, and a cut is made outwards in such a manner that the skin is left longer than the muscles. The knife is then passed behind the bones, and the posterior flap made in a similar manner.

This practice of fashioning flaps by the " transfixion method " has been discontinued almost entirely, and rightly so, on account of the long and large instruments which are necessary for its performance, the large sterilisers which must be available for their efficient sterilisation, and also on account of the possibility of slitting the large blood vessels for the entire length of the wound.

(*c*) *By dissection.*—This mode of forming an amputation flap is only occasionally employed. The shape of the flap is first marked out by making an incision in the skin and superficial fascia. These structures are retracted for a short distance, and then the muscles are divided and dissected up from the bone, so that the muscular flap has the shape of the original skin incision.

Size of flaps.—The two flaps together have to cover the raw surface of the limb at the place of section, and hence must correspond with this in size, due allowance being made for retraction by the divided muscles. Two points must therefore be kept constantly in view—(1) That shrinkage in the flap always occurs immediately after division of the muscular strata, and also at a later period ; and (2) that full allowance for this shrinkage must always be made. A general rule, which may be adopted as regards the length of amputation flaps, is that the length of the two flaps together should be equal to one and a half times the diameter of the limb at the level of the plane of section of the bone (in the thigh they should be a little longer than this), and that in width they should each be half the circumference of the limb at the same level.

The question of contractility of flaps in amputations is of especial importance to the surgeon who has gained most of his experience in the performance of amputations in one or more courses of operative surgery on the dead body. On this account, experience which has been gained by operations upon dead material must be modified when a student commences to operate on the living tissues, in which the elastic and muscular tissues invariably contract or retract when they have been divided with the scalpel. When performing an amputation upon the living subject for the first time, the surgeon should take precautions to ensure that the flaps when fashioned are sufficiently long to cover the end of the stump after retraction has taken place and to rather err in making them too long than too short. If it should so happen that they are too long it is an easy matter to remedy this defect ; whereas, if they are too short, a re-amputation has to be performed either then or at a later period.

For nearly all amputations to the upper and lower limb, the long anterior flap is the one of choice. With this flap the resulting scar is placed posteriorly and above the end of the stump in the one position where it is least likely to be subjected to pressure by the " bucket " of an artificial limb. An exception to this rule is found in Syme's amputation, where a long posterior flap is used because of the exceptional weight-bearing properties of the skin of the heel.

Muscle.—After fashioning the skin flaps the muscle must be severed well below the level of proposed section of the bone. This will allow for the retraction of the tissue which takes place as soon as it is cut. At a later stage of the operation muscle may be fixed to the periosteum, but it is not required as a covering for the end of the bone; in fact, it should never be used for this purpose, as it makes the stump unstable and later becomes converted into fibrous tissue which is nearly always painful.

Bone.—The periosteum must be cut through half an inch above the level of the section of the bone and the distal portion scraped down with a rugine, leaving bare bone at the end of the stump. When the periosteum is removed in this way, there is less likelihood of the formation of a bone spur in the stump. The bone is next completely sawn through with the weight of the distal part of the limb supported to prevent the sudden solution of continuity of the bone occurring by fracture. The sawn end of the bone should be rounded off with bone forceps, a gouge or chisel and mallet.

Nerves.—Each nerve in the stump must be pulled down and its trunk crushed with pressure forceps about one inch above its cut end. The force of crushing must be sufficient to rupture all the nerve fibrils in the sheath, whilst leaving the sheath intact. The sheath at the point of crushing is next transfixed with a round-bodied needle armed with fine catgut and lightly ligatured. This procedure confines the growing nerve fibrils to the nerve sheath above the ligature and prevents the formation of painful amputation neuroma. It is as important to deal with small nerves in this manner as with large nerves ; this must be remembered particularly in amputation of the fingers, where a painful stump may impair the whole function of the hand.

Position of operator and assistant.—In all operations on the extremities above the wrist and ankle respectively, except in disarticulation at the left hip-joint, and in removal of the upper extremity, the operator should stand on the outside of the affected limb on the right side of the body, and inside on the left. His assistant in all cases should stand on the opposite side, somewhat nearer the trunk.

When possible, in amputation operations, it will be found advisable for the operator to grasp the limb at the seat of proposed section of the bone with his left hand, so as to form a ready guide to the eye whilst fashioning the flaps.

Instruments for amputation or disarticulation. — Any amputation or disarticulation can be performed with a small number of instruments, the only special ones being a saw of suitable size and shape, according to the part which is to be removed, a pair of bone forceps, and a periosteal elevator. An elastic constrictor or tourniquet should always be at hand, in order to control the circulation when necessary.

AMPUTATIONS AND DISARTICULATIONS IN THE UPPER EXTREMITY

Removal of digits.—*General considerations.*—The removal by operation of a portion of the upper extremity, especially a portion of the hand, must only be carried out after the most careful consideration by the operator of the best possible functional result which may be obtainable. The prehensile and grasping functions of the fingers and hand must never be lost sight of in the treatment of injuries and inflammatory and suppurative affections of these parts. Conservative and restorative surgery here finds the greatest scope for its intelligent practice, and on this account it is in the hand that the greatest number of irregular and atypical operations are performed. None of the artificial substitutes which are made to replace a hand are of the same value in producing the normal movements of the part, and therefore it behoves the surgeon to save as much as is possible of the different parts of the hand. This remark applies with especial force to the treatment of injuries and diseases of the thumb, since this digit is of the utmost importance in carrying out the important functions of seizing and grasping various objects.

As a general rule, it may be asserted that the skin on the palmar aspects of the digits is the most suitable for forming a flap-covering to an amputation wound, on account of its extensive vascular and nervous supply ; therefore, other circumstances being equal, it is strongly advised that the surgeon should, as far as is feasible, utilise the tissues from this aspect when fashioning flaps. When, however, unnecessary or even harmful shortening of a mutilated or diseased digit can be partially or completely prevented by obtaining flaps from the lateral or dorsal aspects, then in every instance of this kind the surgeon should not hesitate to modify his proceedings so as to obtain the best functional result. As regards removal of a portion of the nerves which supply a digit, this is not possible in the same way as in the more proximal parts of the extremity, where the nerve trunks are of much larger calibre, and can be seen readily without carrying out a careful dissection. Special attention is not directed to this point, on account of the difficulties in carrying it out, and also of the unnecessary and harmful injury which is inflicted on the tissues of the flaps.

In order to obtain the best functional result, it is advised, after removal of a portion of a digit, whether through one of the phalanges or either of the interphalangeal joints, that the flexor and extensor tendons should be united together, over the end of the bone, by a few points of suture, and also fixed in a similar manner to the periosteum of the adjacent portion of the phalanx.

When a disarticulation of a digit is performed at a metacarpophalangeal joint, the head of the metacarpal bone should be left in every case where it is important and desirable that the best possible functional result should be obtained. When, however, the appearance of the hand is considered to be of more importance than the retention of its functions, as is often the case when dealing with ladies or men of the professional and higher classes, then the head of the metacarpal bone and the adjacent portion of the shaft should be removed.

A finger may be amputated through the second interphalangeal joint, the first interphalangeal joint, or the metacarpo-phalangeal joint ; or one of the phalanges may be divided, or the entire digit may be taken away together with its metacarpal bone.

Anatomical considerations.—Position of the joints.—When the digits are partially flexed three prominences are apparent on their dorsal aspect in the neighbourhood of the metacarpo-phalangeal and interphalangeal joints. In each case the joint lies distal to the prominence, this being formed by the head of the metacarpal bone or phalanx. The metacarpo-phalangeal joint is situated about one-third of an inch distal to the prominence of the knuckle ; the first interphalangeal joint one-fifth or one-sixth of an inch beyond the prominence formed by the distal extremity of the first phalanx, and the second interphalangeal joint about one-tenth of an inch distal to the prominence formed by the head of the second phalanx. On the palmar aspect of the digits three transverse furrows are visible, the proximal one two-thirds of an inch distal to the plane of the metacarpo-phalangeal joint, the middle one directly opposite the first interphalangeal joint, and the third or distal crease about a quarter of an inch proximal to the line of the corresponding joint.

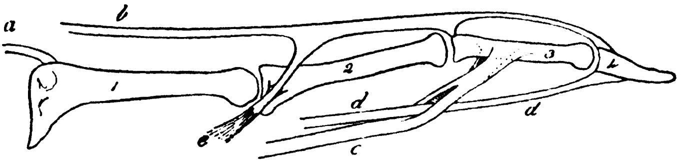

FIG. 481.—Diagrammatic representation of the manner in which the flexor and extensor tendons are inserted into the fingers.

1. Metacarpal bone.
2. First phalanx.
3. Second phalanx.
4. Third phalanx.
a. Tendon of exterior of metacarpal bone.

b. Extensor communis tendon.
c. Flexor sublimis tendon.
d. Flexor profundus tendon.
e. Tendon of a lumbrical or interosseous muscle.

Ligaments.—The strong ligaments of the metacarpo-phalangeal and interphalangeal joints are the two lateral ones. The palmar ligament is of medium thickness, whilst on the dorsal aspect the aponeurosis of the extensor tendon takes the place of a ligament.

Insertion of tendons.—The tendons of the flexor digitorum profundus are inserted into the palmar aspect of the basis of the distal phalanges ; those of the flexor digitorum sublimis into the lateral aspects of the shafts of the second phalanges ; the slips from the interossei and lumbricales and the extensor expansion into the lateral aspects of the basis of the first phalanges ; and the extensor digitorum communis into the dorsal aspect of the basis of the second and third phalanges (Fig. 481).

Sheath of the flexor tendons.—On the palmar aspect of the first and second phalanges there is a well-marked fibrous canal, lined by a synovial sheath, and containing the flexor tendons.

Amputation through the distal interphalangeal joint.—The following varieties of operation have been made use of :—

(*a*) Long palmar flap.

(*b*) Long palmar and short dorsal flaps.

Special instruments.—Narrow-bladed scalpel and short finger-knife, and the ordinary instruments for an amputation.

Position.—The hand is pronated, and the adjacent fingers held aside by two strips of aseptic gauze by an assistant. The surgeon stands or sits facing the limb.

Operation.—(*a*) *By a long palmar flap.*—The phalanx to be removed is firmly grasped by the left hand of the surgeon, and the second interphalangeal joint flexed. A transverse incision is made across the dorsal aspect of the joint, extending half-way round the digit. This incision should open the joint. The lateral ligaments are divided, and the edge of the knife, after cutting through the palmar ligament, is turned towards the tip of the finger, and then, by a slight sawing movement, a flap is cut. Care must be taken to make the extremity of the flap almost square, so as to correspond with the dorsal incision. It usually comprises about two-thirds of the pulp of the finger (Figs. 481 and 483).

Any bleeding vessels present are ligatured, and then the flap is turned over the free extremity of the second phalanx and stitched to the margins of the dorsal incision.

If a narrow-bladed knife is not available, the palmar flap may be dissected up first with the scalpel, and the disarticulation performed from the dorsal aspect as before.

(*b*) *By a short dorsal and a long palmar flap.*—In this case a short dorsal flap, one-third the length of the palmar, is dissected up before the opening joint. The other stages of the operation are similar to the preceding, with the exception that the palmar flap is correspondingly shorter.

Amputation through the second phalanx of a finger.—Whenever possible the amputation should be performed through the distal third of this phalanx, in order to preserve the insertions of the tendon of the flexor sublimis digitorum. Whether this is practicable or not, the divided extremities of the extensor and flexor tendons should be sewn together over the exposed end of the bone, so as to render movements of the remaining portion of the digit as useful as possible.

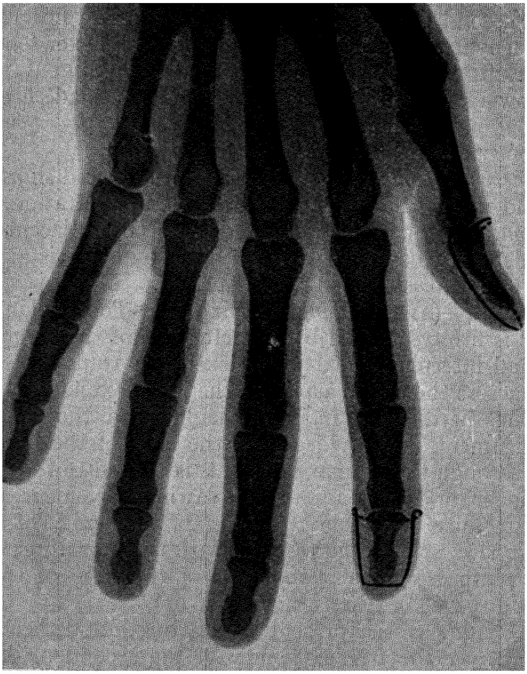

FIG. 482.—Finger and thumb, showing position of skin incisions in amputation of distal phalanx by a long palmar flap.

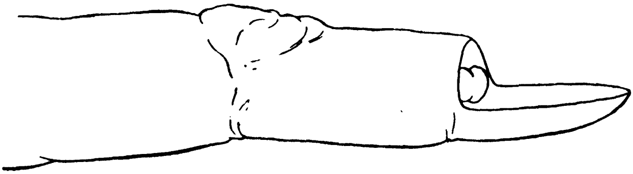

FIG. 483.—Finger from which the terminal phalanx has been removed, showing a long palmar flap.

The amputation may be performed by the following methods:—
(*a*) Long palmar flap.
(*b*) Short dorsal and long palmar flaps.
(*c*) Equal antero-posterior flaps.

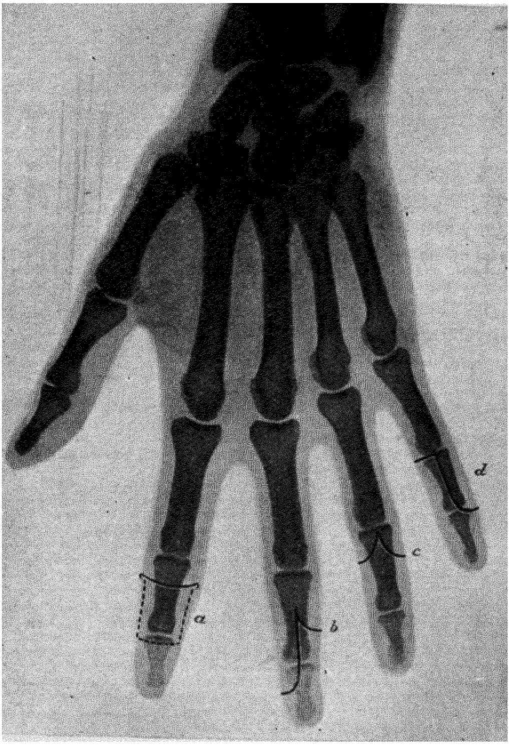

FIG. 484.—Amputation of a finger through second phalanx.

a. By long palmar flap.
b. By unequal lateral flaps.
c. By equal lateral flaps.
d. By a single long lateral flap.

(*d*) One long lateral flap.
(*e*) Two equal lateral flaps.
(*f*) Equal lateral flaps.

The first two of these methods are the best, and should be adopted whenever the conditions of the part will allow (Fig. 484).

(*a*) *By a long palmar flap.*—The hand being held as in the previous operation, the operator decides upon the level at which he will divide the bone. An incision is then made round half the circumference of the digit on its dorsal aspect, at the level of the proposed plane of section of the bone. The point of the knife is then entered at one extremity of this incision, passed transversely across on the flexor aspect of the phalanx, emerging at the opposite side of the digit. By a series of sawing movements a palmar flap ⅔ to ¾ inch is made, and the edge of the knife then turned towards the palmar surface and made to cut its way out-

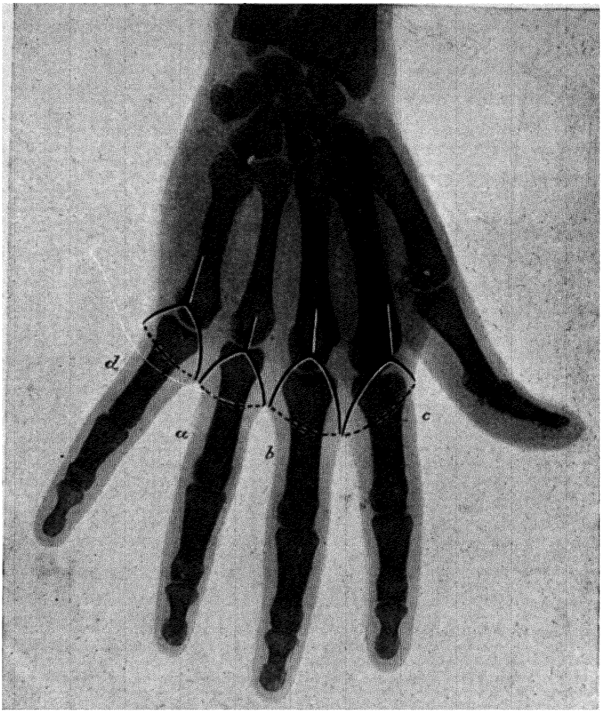

FIG. 485.—Position and shape of incision in amputation of a finger through the metacarpo-phalangeal joint.

a. Without removal of head of corresponding metacarpal bone.
b. With removal of head of metacarpal bone.
c. Index finger. *d.* Little finger.

wards. The soft parts are retracted for a short distance, the periosteum divided, the section of the bone made with a finger saw, and the distal portion of the digit removed.

Hæmorrhage is arrested, the divided tendons united and fixed to the periosteum, and the flap is then turned over the end of the finger and sutured in position.

(*b*) *By a short dorsal and a long palmar flap.*—A short dorsal flap, one-third the length of the palmar one, is dissected up, and then the palmar flap is fashioned as in the preceding case, but cut somewhat shorter. The further stages of the operation are similar to the preceding.

(*c*) *By equal antero-posterior flaps.*—The plane of section of the bone having been determined, an incision is made commencing at the lateral aspect of the finger, passing downwards for ½ or ¾ inch, then transversely across the dorsum, and upwards on the opposite side. The flap so marked out is dissected upwards, and a similar flap made on the palmar surface. The flaps are retracted, the tendons cut across, the periosteum divided, and the bone sawn through.

Hæmorrhage is arrested, the tendons united together and fixed to the periosteum, and the margins of the flaps united with sutures.

(*d*) *By one long lateral flap.*—The plane of section of the bone having been decided upon, a vertical incision is made along the middle line of the dorsal aspect of the finger, commencing at this level and extending downwards for ¾ inch. The incision is carried round to the palmar aspect of the finger, and then upwards along the middle line on the palmar surface to a point opposite that at which it commenced. The flap, consisting of skin and fasciæ, is dissected up to the plane of section. Then with the scalpel the soft tissues on the opposite side of the finger are divided transversely, together with the flexor and extensor tendons, and the bone sawn through.

Hæmorrhage is arrested, the divided tendons sutured together over the end of the bone and fixed to the periosteum, and finally the flap is adjusted over the end of the finger and fixed in position by sutures.

(*e*) *By two unequal lateral flaps.*—The details of this operation are similar to those of the preceding, with the exception that a short flap is dissected back on one side and a longer one on the other.

(*f*) *By equal lateral flaps.*—The incision in this operation is similar to that in the preceding, but it is carried for a shorter distance along the dorsal aspect of the finger, and two flaps of equal length are cut.

Amputation through the proximal interphalangeal joint.—The best operation for this purpose is that in which a long palmar and a short dorsal flap are made.

Operation.—The level of the joint being defined, a short dorsal flap, ⅓ inch in length, is dissected back. The joint is then opened from above, and the palmar flap, ⅔ inch in length, formed by cutting distally on palmar aspect of the phalanx.

Hæmorrhage is arrested, the extensor expansion on the dorsal aspect of the phalanx, and the flexor tendons on the palmar aspect, brought over the end of the phalanx, joined together, and fixed in position with sutures. The palmar flap is then adjusted to the dorsal one, and the margins united in the usual manner.

Amputation of a finger through the metacarpo-phalangeal joint.—This is usually done by means of a "racket-shaped" incision. The finger which is to be removed being firmly grasped by the left hand of the surgeon, and the adjacent fingers being held aside with strips of aseptic gauze by an assistant, the incision is commenced in the middle line over the dorsal aspect of the corresponding metacarpal bone, ⅓ inch from its distal extremity. It is continued downwards to the level of the joint, and then round one side of the finger across the palmar aspect just beyond the web, and up the other side till it reaches the vertical incision again. The flap having been dissected up on each side, the extensor tendon is divided, and disarticulation is performed from above. Any bleeding digital arteries are ligatured, the flexor and extensor tendons anchored by sutures to the periosteum, and the two flaps are brought over the convex extremity of the metacarpal bone and fixed by the insertion of sutures.

If the patient is a lady or belongs to the upper classes, and the appearance of the hand is considered to be of more importance than the utility for physical labour, the head of the metacarpal bone should be removed. This is effected by dissecting back the tissues covering it for a short distance, cutting through the transverse metacarpal ligament, and then dividing the shaft with a fine metacarpal saw. Bone forceps should not be used for this purpose, since they are liable to cause splintering of the bone. The later stages of the operation are as before.

Amputation of a finger together with its metacarpal bone.—The plane of the carpo-metacarpal joint having been determined, an incision is made along the dorsal aspect of the metacarpal bone for its proximal two-thirds, and then round the finger just beyond the web in an oval manner, as in the preceding operation. The flaps are dissected away from the bone, the dorsal interosseous muscles being detached, and then with the point of the knife the carpo-metacarpal ligaments are cut through. Care must be taken in this part of the operation not to allow the point of the knife to travel into the tissues of the palm, in which case severe hæmorrhage might ensue. When disarticulation has been performed the base of the bone is raised, the soft tissues on its palmar aspect separated, and the digit removed.

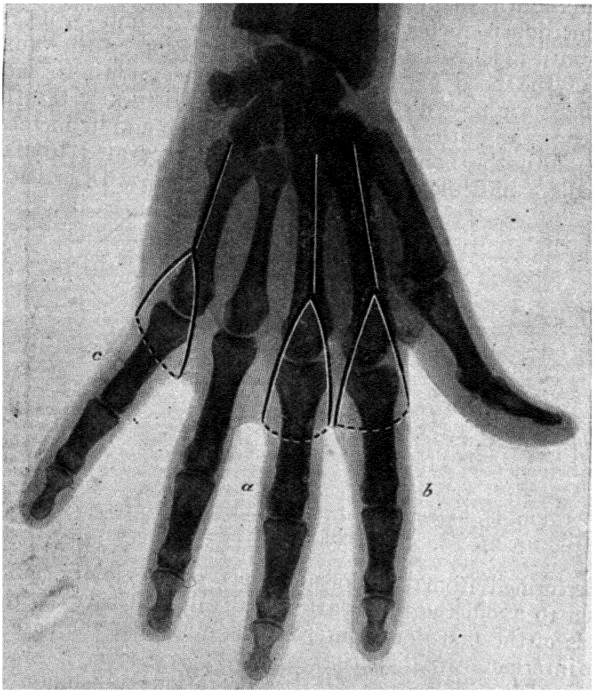

FIG. 486.—Amputation of a finger with the corresponding metacarpal bone.

a. Position of incision for third finger.
b. For index-finger. *c.* Fifth finger.

All bleeding vessels having been ligatured, the margins of the wound are brought together and fixed by the insertion of sutures.

In removal of the little finger with its metacarpal bone the incision is made along the ulnar side and not on the dorsal aspect.

Amputation of the thumb at the carpo-metacarpal joint.—The distal part of the thumb being held by the left hand of the surgeon, an incision is made which commences over the base of the metacarpal bone on the radial side. This extends downwards to a point a short distance above the head of the bone, then obliquely round the dorsal and ulnar aspects of the first phalanx until the middle of the palmar aspect is reached. The incision is then continued round the thumb on its radial side, until it joins the first part of the incision on the proximal side of the head of the metacarpal bone. With the scalpel two flaps are now dissected up from the tissues of the thenar eminence and of the ulnar side of the thumb and its metacarpal bone, until the bones are exposed and separated from their immediate muscular and fascial connections. Disarticulation is performed from the dorsal aspect of the joint, care being taken to avoid the radial artery as it dips in between the two heads of the first dorsal interosseous muscle at the base of the first intermetacarpal space.

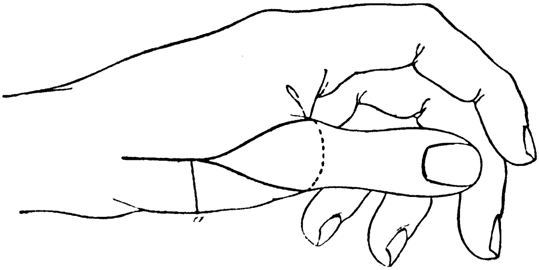

FIG. 487.—Removal of thumb at carpo-metacarpal joint.
a. Position of skin incision.

For the performance of this operation transfixion of the thenar eminence has been recommended, but in my opinion is not necessary. Section of the soft tissues is readily and effectively carried out by the procedure described.

When the thumb has been removed in this manner, all bleeding vessels are seized with forceps and ligatured. Finally, the flaps are brought together and fixed by the insertion of sutures.

Whenever possible a portion of the metacarpal bone of the thumb should be left, for the reasons which have already been discussed (p. 715).

Amputation at the wrist-joint.—The general rules to be observed in the performance of an amputation through the neighbourhood of the wrist are: that as much as possible of the limb should be preserved, that the inferior radio-ulnar joint should not be opened, and that the covering for the extremities of the bones should be derived chiefly from the tissues of the palm.

Indications.—(*a*) Extensive tuberculous affections of the wrist, together with other chronic inflammatory conditions of the carpus which cannot be satisfactorily treated by excision.

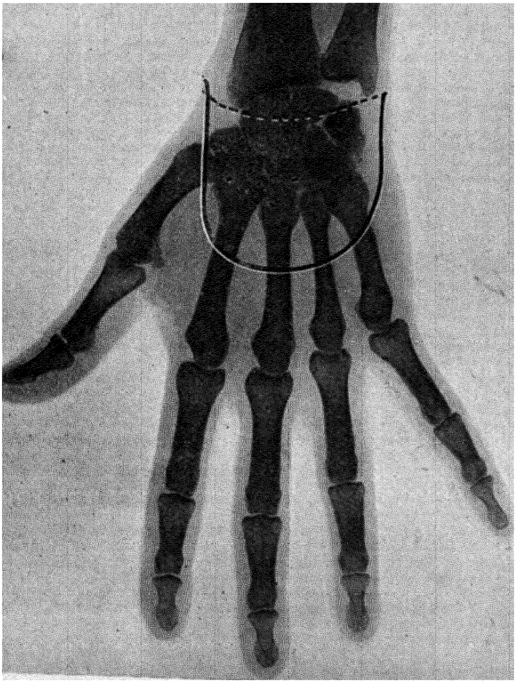

FIG. 488.—Amputation at the wrist by long palmar and short dorsal flaps. The dark line represents the palmar flap, and the dotted line the dorsal one.

(*b*) Severe injuries which cause destruction of the distal part of the hand.

(*c*) Occasional cases of contraction of the hand following burns.

(*d*) Some cases of very advanced Dupuytren's contraction.

(*e*) Some cases of multiple enchondromata of the bones of the hand.

(*f*) Certain cases of malignant disease of the hand such as carcinoma, squamous-celled, and sarcoma, in which a less serious operation is not thought to be desirable.

The best form of amputation through the wrist-joint is by a long palmar and a short dorsal flap. Other methods are by equal antero-posterior flaps, by a long external lateral flap, and by the circular method.

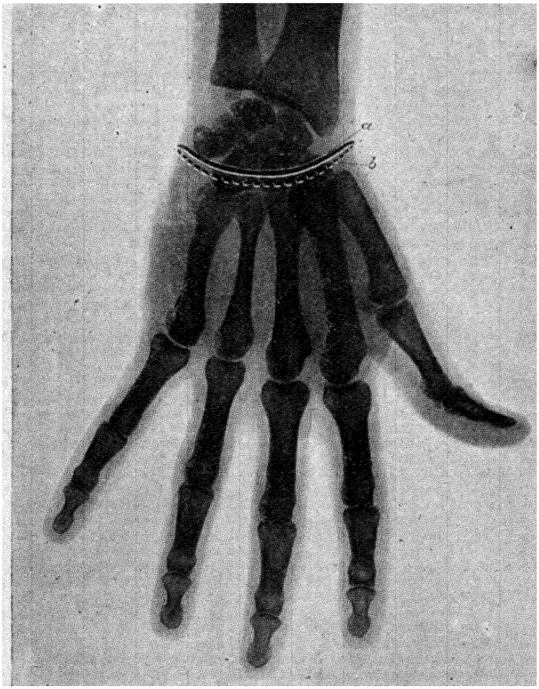

FIG. 489.—Amputation of the wrist by equal dorsi-palmar flaps.
a. Dorsal incision. *b*. Palmar incision.

(*a*) *By a long palmar and a short dorsal flap.*—*Position.*—The patient is placed in the dorsal position, with the arm at right angles to the side, the forearm supinated, and the hand resting on the arm out of the operation table or on a small table. The surgeon stands or sits opposite the end of the limb, and the assistant opposite to him. A second assistant controls the circulation in the brachial artery, either by digital pressure or by applying some form of tourniquet.

Operation.—The surgeon grasps the fingers with his left hand, an assistant abducts the thumb, the wrist is extended, and the positions of the styloid processes of the radius and ulna defined. An incision is then made, commencing at the styloid process of the radius, passing vertically downwards over the thenar eminence to the middle of the palm, then transversely across the palm, and upwards over the hypothenar eminence to the styloid process of the ulna. The free extremity of this flap should be slightly convex (Fig. 488). The flap is dissected up, and made to include the deep palmar fascia, and if possible the

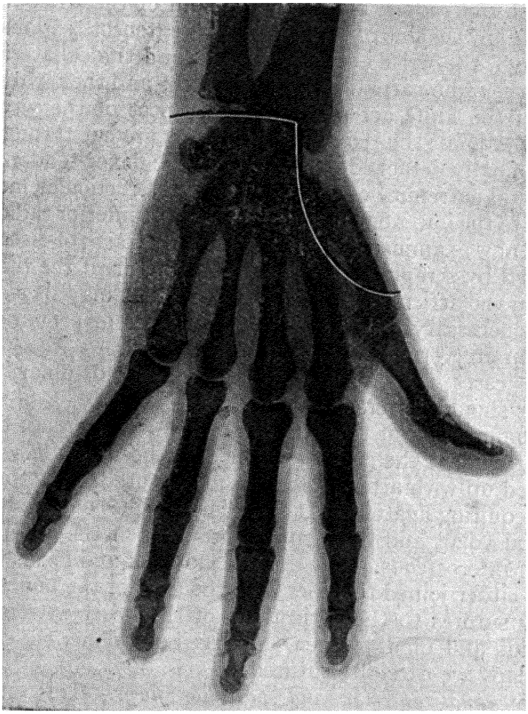

Fig. 490.—Amputation of the wrist by a long lateral flap. Position of skin incision.

superficial palmar arch as well as in its upper part, portions of the muscles of the thenar and hypothenar eminences, so as to preserve a good blood supply to the part (superficial volar and superficial branch of the ulnar artery).

The hand is now pronated and strongly flexed at the wrist, and a dorsal incision made from the styloid process of the ulna to that of the radius, across the dorsum of the wrist a short distance below the line of the joint. The extensor tendons being cut through, the wrist is further flexed, and the collateral ligaments of the radio-carpal joint are divided ; and then, with a few strokes of the knife across the dorsal aspect of the wrist and through the joint, the remaining ligaments are cut through, and the hand finally detached by division of the flexor tendons.

The distal extremity of the radius, the interarticular meniscus attached to the lower end of the ulna, and the inferior radio-ulnar joint, are now examined, and if there are any traces of disease this is removed by scraping with a sharp spoon, or, if the disease is extensive, the articular surfaces of both bones may be sawn off. If this is necessary, however, the movements of pronation and supination are very seriously interfered with.

In all cases the apices of the radial and ulnar styloid processes should be removed.

The compression of the brachial artery is now relaxed, so as to render evident the arteries which have been divided. These are picked up with artery forceps and ligatured. The principal vessels requiring ligature are the radial branches of the ulnar, the superficial volar, and the terminal branches of the anterior and posterior interosseous. The divided extensor and flexor tendons are now either joined together over the ends of the bones, or are fixed by sutures to the periosteum of the lower extremities of the radius and ulna. When this has been done, the cutaneo-fascial flaps are carefully sutured.

(*b*) *By equal anterior and posterior flaps.*—This operation may be performed when the condition of the skin of the palm does not allow of the previous operation being carried out. The details of the operation are similar to the preceding, with the exception that the two flaps are made of equal length (Fig. 489).

(*c*) *By a long external lateral flap.*—This method of operating should only be made use of when all the tissues of the ulnar side of the hand are extensively diseased or injured, and the distal part of the thumb is also rendered useless.

Operation.—An incision is made which commences on the dorsal aspect of the wrist, somewhat nearer to the radial than the ulnar side, passes first downwards, then outwards, crossing the metacarpal bone of the thumb just below its head, then upwards over the thenar eminence, terminating at a point in front of the wrist corresponding to the point of commencement on the dorsum. A horizontal incision is next made at the level of the wrist-joint, commencing at the dorsal extremity of the first incision, extending round the medial side just below the styloid process of the ulna, and ending at the palmar extremity of the primary incision (Fig. 490). The flap which has been outlined on the outer side is dissected up, care being taken to include in it some of the muscles of the thenar eminence. The flap is well retracted, the flexor and extensor tendons divided, and disarticulation performed, the joint being opened from the outer side.

The bones, the bleeding vessels, and the divided tendons are treated as in the preceding operation, and finally the flap is brought over the extremities of the radius and ulna, and fixed in position by the insertion of sutures.

(*d*) *By the circular method.*—The skin of the forearm is drawn well upwards by the assistant, and a circular incision made through skin and superficial fascia at the level of the carpo-metacarpal joints. This will include the proximal parts of the thenar and hypothenar eminences. The skin is then further retracted or dissected backwards in the form of a cuff, and the deep fascia and the underlying tendons cut through. These structures are retracted for a short distance, and then the wrist-joint is opened and the hand removed.

The vessels are secured, the bones and divided extensor and flexor tendons treated as before, and then the soft parts are drawn over the extremities of the limb and fixed by the insertion of sutures.

Amputation through the forearm.—An amputation through the forearm may be performed in the following ways :—

(*a*) By unequal skin-flaps, longer dorsal and shorter palmar, with circular division of the muscles.

(*b*) By lateral flaps.

(*c*) By the circular method. This last mode of operation is most suitable for amputation through the distal third of the forearm ; it cannot be satisfactorily practised in the proximal part.

In the majority of instances, when performing amputations through the forearm and disarticulation at the elbow-joint, the best results and the most satisfactory stumps can be obtained by adopting the method of " antero-posterior " cutaneo-fascial flaps with deeper division of muscles, the flaps being of unequal length. There is not much to choose between a long anterior and a short posterior flap and the reverse, although, in my opinion, a more satisfactory stump is obtained by making the long flap anterior. Often, however, owing to the nature of the disease or injury, and the parts of the forearm which are most extensively involved, better results can be gained by making lateral unequal flaps; and when this is the case the surgeon should not hesitate to adopt one of these methods in preference to the antero-posterior one. An important factor in ensuring a movable stump is careful suturing of the periosteum and flexor and extensor tendons, as already recommended and described.

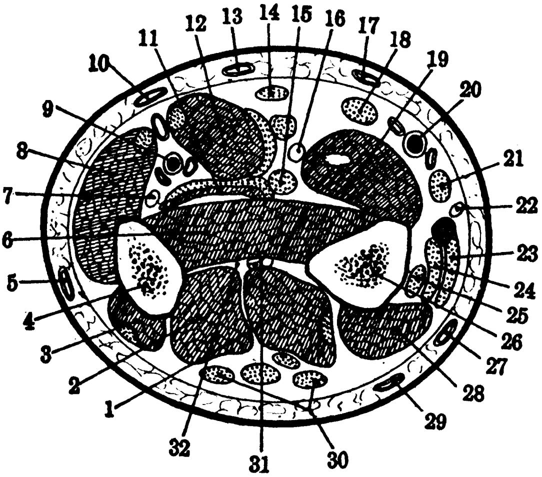

FIG. 491.—Transverse section of forearm through proximal portion of distal fourth.

1. Extensor pollicis longus (extensor secundi internodii pollicis).
2. Extensor indicis proprius.
3. Extensor carpi ulnaris.
4. Ulna.
5. Tributary of anterior ulnar vein.
6. Pronator quadratus.
7. Ulnar nerve.
8. Flexor carpi ulnaris.
9. Ulnar artery and venæ comites.
10. Anterior ulnar vein.
11. Flexor digitorum profundus.
12. Flexor digitorium sublimis.
13. Superficial median vein.
14. Palmaris longus.
15. Lateral tendon of flexor digitorum profundus..
16. Median nerve.
17. Anterior radial vein.
18. Flexor carpi radialis.
19. Flexor pollicis longus.
20. Radial artery.
21. Brachio-radialis (supinator longus).
22. Superficial branch of radial nerve.
23. Abductor pollicis longus.
24. Extensor carpi radialis longus.
25. Extensor carpi radialis brevis.
26. Radius.
27. Posterior radial vein.
28. Extensor pollicis brevis (extensor primo internodii pollicis).
29. Superficial vein.
30. Extensor digitorum communis.
31. Anterior interosseous vessels and nerve.
32. Radio-ulnar interosseous membrane.

(*a*) *Amputation through the forearm by antero-posterior flaps.*

—The limb is prepared in the usual manner for an amputation, and an Esmarch's elastic tourniquet is applied to the distal third of the arm, in order to compress the brachial artery and control hæmorrhage.

Special instruments.—The most suitable knife is a small amputating knife, with a blade 3 or 4 inches in length. The saw is the usual amputation saw.

Position.—The affected limb is fully extended, with the forearm pronated and held by an assistant. The surgeon stands on the lateral side of the limb in the case of the right arm, and on the medial side in the case of the left. His assistant stands opposite to him.

Operation.—The plane of section of the bones having been decided upon, the surgeon grasps the forearm with the left index finger and thumb at this level. With the knife an incision is made, which commences at the level of the plane of section and passes vertically downwards for 2 or 3½ inches, according to the size of the limb, and then transversely across the extensor aspect to a point on the medial side half-way round the limb, the end of the flap being made slightly convex. The incision is completed by continuing it along the medial margin of the limb to the level of the plane of section of the bones. The flap thus marked out is dissected up by a series of light strokes with the knife ; it should consist of skin, superficial and deep fascia, and at its base, of some muscle. When the flap has been dissected up it is retracted by the assistant, and the hand is supinated.

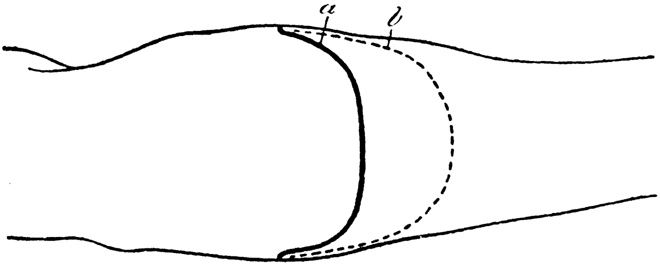

FIG. 492.—Amputation of the forearm by antero-posterior flaps.
a. Line of anterior incision. | b. Line of posterior incision.

The second flap, which should be from 1½ to 2½ inches in length, is formed on the palmar aspect of the limb by sweeping the knife from the ulnar to the radial side in a slightly curved direction, so as to give its extremity a broadly convex outline.

It is dissected up in a manner similar to the preceding, and then both flaps are fully retracted by the assistant.

The muscles are next divided by a series of circular cuts down to the bone, the periosteum is cut through at a point ⅔ inch below the level at which the saw is to be applied, and separated upwards for this distance with a periosteal elevator. The bones are then sawn across. In doing this, care must be taken not to cause splintering. This is avoided by the assistant holding the limb steady, and the surgeon sawing with a series of light sweeps. The forearm should be fully supinated while the bones are being sawn.

The blood vessels, of which there are four main ones,—radial, ulnar, and anterior and posterior interosseous,—are sought for and ligatured. The radial lies under cover of the brachio-radialis, in close proximity to the radius. The ulnar lies beneath the flexor carpi ulnaris, anterior to the ulna. The anterior interosseous lies on the anterior aspect of the interosseous membrane. The posterior interosseous in the upper part of its course lies between superficial and deep layers of muscles, whilst in the distal third of the forearm it is generally on the interosseous membrane.

The " cuffs " or flaps of periosteum are sutured over the ends of the bones.

Any tags of tendon which may appear on the surface of the wound are cut away, if necessary, and the cut ends of the flexor and extensor tendons united by sutures, or fixed to the periosteum. The flaps are next brought over the ends of the bones, and fixed together by the insertion of sutures.

(*b*) *By lateral flaps.*—In performing an amputation through the forearm by the lateral flap method, the incisions are made in a vertical direction along the dorsal and palmar aspects of the limb. In other respects the operation is similar to that above described.

Some surgeons recommend that the flaps should be formed by transfixion, but this method presents no advantage over the one detailed above; and, moreover, the flaps cannot be shaped with such great accuracy.

(*c*) *By the circular method.*—This operation is only suitable for an amputation through the distal third of the forearm.

Position.—The limb is extended and abducted, the forearm supinated, and the hand held by an assistant. The surgeon stands on the radial side when operating upon the right limb, and on the ulnar side when operating upon the left.

Operation.—The level of the section of the bone having been marked out, the left hand of the surgeon retracts the skin upwards. Then the knife is passed round the limb from below, and a circular incision is made 2 to 3 inches distal to the plane of section. This incision divides the skin, superficial and deep fasciæ, and then these tissues are dissected upwards as far as the level at which the bones are to be sawn. It is usually convenient to turn them back in the form of a cuff. A second circular incision is now made through all the remaining soft tissues down to the bones, the muscles being allowed to retract, and the periosteum divided at a slightly higher level. The periosteum is separated from the bones for about ½ inch, and then the bones are sawn across. The blood vessels are ligatured, the periosteum and tendons fixed by sutures, and the soft parts are drawn over the end of the stump and sutured in the usual manner.

Amputation through the elbow-joint.—This may be performed by the following methods :—

(*a*) By antero-posterior flaps.
(*b*) By unequal lateral flaps.
(*c*) By the elliptical method.
(*d*) By the circular method.

The best methods of amputating through the elbow-joint are by a long anterior and short posterior flap, and by the elliptical method. Both these operations provide a thick muscular covering, well supplied with blood vessels, for the end of the humerus.

The circular method is easy in its performance, and gives a small wound, but does not afford such a good covering for the end of the bone, while the scar is left in an exposed situation.

The anterior and lateral aspects of the lower extremity of the humerus are well covered with muscles, the posterior aspect being more superficial. The medial epicondyle is situated at a lower level than the lateral, and is more prominent. This must be borne in mind when disarticulating.

(*a*) *By a long anterior and a short posterior flap.*—Hæmorrhage is controlled by the application of an Esmarch's elastic tourniquet to the middle of the upper arm.

Position.—The limb is somewhat abducted from the side, and held by an assistant in a position of complete supination, with the elbow slightly flexed. The operator stands on the radial side of the right limb, and on the ulnar side of the left limb.

Operation.—The positions of the medial and lateral epicondyles of the humerus are determined, and a point selected 1 inch distal to the medial, and another 1½ inches distal to the lateral. With a short amputation knife an incision is made which commences at the first point (in the case of the right limb), extends distally along the ulnar margin for 3 inches, then almost transversely across the front of the forearm, and upwards on the lateral side to the point 1½ inches distal to the lateral epicondyle.

The extremity of the flap is cut somewhat convexly, and then dissected upwards. The flap at first consists of the skin and fasciæ, and then of muscle as well.

The margins of the first incision are joined across the posterior aspect of the limb by making a cut from one side to the other, in such a manner that a flap about one-third the length of the anterior is fashioned. This is dissected back to its base, and then both flaps are well retracted by the assistant. Any remaining muscles or other soft tissues in front of the joint are now divided. The joint is opened on the lateral side, the ligaments cut through, and disarticulation completed by cutting out behind. The tendon of the triceps brachii is the last part to be divided. The brachial artery is secured as it lies in front and almost in the centre of the stump, the elastic tourniquet is relaxed, and the various small vessels of the arterial anastomosis about the elbow-joint picked up with artery forceps, and ligatured. The main nerve trunks are dissected free for 1 inch above the plane of section of the limb, cut through, and removed. The flaps are then brought into apposition, and fixed by the insertion of sutures, after uniting the divided muscles and tendons with several points of suture over the end of the bone, and fixing them to the ligaments.

It is usually advisable to leave one angle of the wound open, so as to provide for the escape of secretion from the remaining part of the synovial membrane of the joint.

(*b*) *By unequal lateral flaps.*—If this method is employed the incision is made from the front of the elbow-joint, terminating behind the olecranon. The long flap may be either external or internal, according to the state of the tissues at the time of operation.

(*c*) *By the elliptical method.*—The proximal extremity of the ellipse should be situated on the extensor aspect of the limb, immediately above the proximal border of the olecranon and the distal extremity on the flexor aspect of the forearm, just below the junction of the proximal with the middle third.

An incision is made which marks out the ellipse, commencing above and behind, extending distally to the lowest point in front, and then proximally again to the olecranon behind (Fig. 494). As the surgeon makes this incision, the limb, which is held by an assistant, is rotated so as to expose the parts which are being cut. The skin and fasciæ are retracted and dissected up for a short distance, and then the soft tissues in front of the elbow-joint are divided with the knife, so as to form a muscular anterior flap. This flap is retracted by an assistant, and the remaining soft tissues divided until the anterior aspect of the elbow-joint is laid bare. The joint is opened from the lateral side by dividing the radial collateral and the anterior ligaments, and disarticulation is completed, as in the preceding operation.

Hæmorrhage is arrested, the distal portions of the large nerve trunks excised in the manner recommended, and the margins of the flap brought together and sutured. The resulting scar is situated on the posterior aspect of the stump.

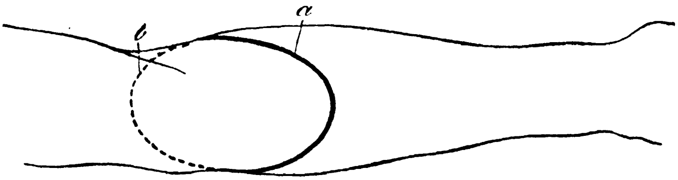

FIG. 493.—Amputation of the elbow-joint. By an elliptical incision.
a. Position of anterior part of incision.
b. Position of posterior part of incision.

Amputation through the arm.—An amputation may be performed through the arm at any point from the tuberosities to the epicondyles of the humerus. Whenever possible a part of the humerus should be left behind, in order to provide a stump to which an artificial limb may be attached.

The forms of amputation which are practised for removal of the limb are, in the distal third, usually the circular method; in the middle and proximal thirds, either the circular amputation or, more commonly, amputation by antero-posterior cutaneo-fascial flaps, with circular division of the muscles.

(*a*) *Amputation by the circular method.—Position.*—The patient is placed in the dorsal posture, with the affected limb abducted and held horizontal. One assistant grasps the hand and forearm so as to manipulate the limb during the operation, and the other stands on the right of the operator. The surgeon stands on the radial side of the right limb and the ulnar side of the left.

Operation.—The site of section of the bone being determined, a circular incision is made through the skin, superficial and deep fasciæ, 2½ to 3 inches distal to the plane of section of the bone.

The divided tissues are dissected upwards, and turned back in the form of a cuff. The superficial muscles are divided and allowed to retract, and then the deeper muscles cut through by making a circular sweep round the limb. Whilst these incisions are being made the limb is rotated, as required, by the assistant who has charge of it.

The bone is then freed from its periosteum for a short distance, and sawn through in the usual manner.

The brachial artery is secured in the antero-medial part of the wound, and a ligature applied. The elastic ligature which controls the brachial artery (or the fingers of the assistant, if digital compression has been made use of) is relaxed, and any bleeding vessels tied. The separated periosteum is sutured over the sawn end of the humerus, the distal portions of the large nerve trunks excised, and the divided muscles sutured to the periosteum, and to one another.

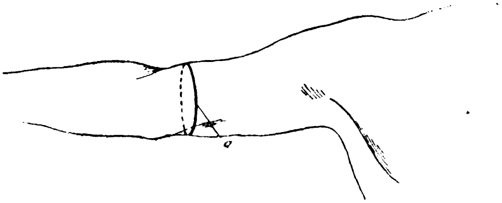

FIG. 494.—Amputation through the arm by the circular method.
a. Skin incision.

The margins of the wound are then brought together in an antero-posterior direction, and united by the insertion of a series of sutures.

(*b*) *Amputation by skin flaps, with circular division of the muscles.*—The relative lengths of the anterior and posterior flaps in this operation depend upon the condition of the tissues of the limb.

As much of the limb as possible should be saved, and the skin flaps taken from the most healthy part.

Position.—The positions of patient, surgeon, and assistant are similar to those of the preceding operation.

Operation.—An incision is made commencing on one side of the limb, extending distally for 3 or 4 inches, then transversely across to the opposite side, and proximally for an equal distance. The width of this flap ought to be half the circumference of the limb. Its distal extremity is made slightly convex.

The incision divides the skin, superficial and deep fasciæ, and then the flap is dissected up to its base by a series of light cuts. Next, a shorter posterior flap, about one-third of the length of the anterior, is fashioned in a similar manner. Both flaps are retracted by an assistant, and the muscles divided by a circular sweep of the knife down to the bone. The periosteum is cut through, separated from the bone, and retracted for a short distance, and the bone sawn across.

Hæmorrhage is arrested in the usual manner, the divided tissues treated as described in the previous operation, and the margins of the flaps united by the insertion of sutures.

In the distal third of the arm the brachial artery lies anterior to the shaft of the humerus, in the proximal two-thirds it lies away from the bone on its medial side (Fig. 496).

In the formation of the flaps some surgeons adopt the "transfixion" method. This presents no advantage, however, over the one above described, and in my opinion ought not to be practised, for reasons already given.

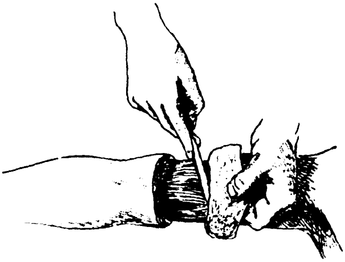

FIG. 495.—Method of dissecting back cuff of skin and fasciæ.

Amputation or disarticulation at the shoulder-joint.—A considerable number of operations have been devised for the removal of the upper extremity at the shoulder-joint. One of the best of these is that by the racket-shaped incision now to be described.

Position.—The patient is placed in the dorsal posture, with the affected shoulder projecting slightly beyond the edge of the operation table, and if necessary a sandbag placed between the shoulder-blades. The surgeon stands on the outer side of the shoulder, one assistant grasps the upper extremity at the elbow and rotates it as required, a second assistant may control hæmorrhage by applying digital pressure to the subclavian artery whilst the third assistant helps the operator by retracing the flaps, seizing bleeding vessels, etc.

Operation.—An incision is made commencing immediately distal to the clavicle, and on the lateral side of the coracoid process. It extends distally for a short distance through the anterior fibres of the deltoid, and through the pectoralis major close to its insertion, winds around the lateral and posterior aspects of the arm, then across the medial aspect just below the folds of the axilla, and finally proximally until it joins the vertical portion of the first incision (Fig. 497). In making the anterior, lateral, and posterior parts of the incision, the tissues are divided down to the bone, but on the medial side the skin and fasciæ alone are divided. The vertical part of the incision should open the capsule of the shoulder-joint. The brachial artery may be sought for now at the medial side of the arm, separated from its connections, ligatured, and cut through. A flap is next dis-

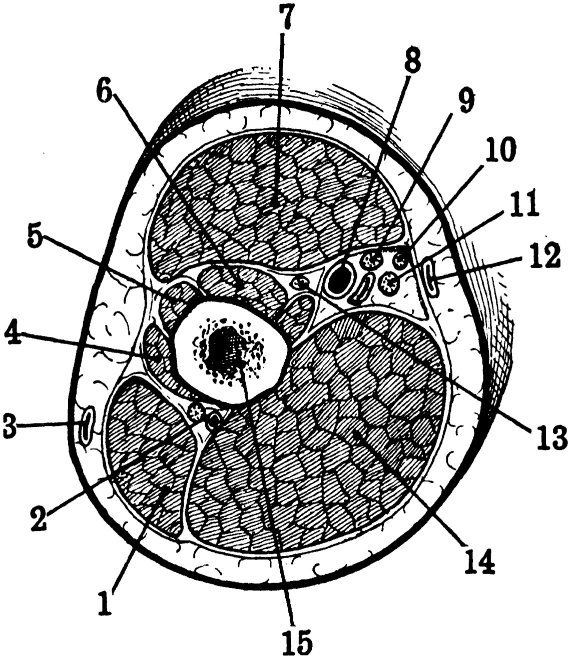

FIG. 496.—Transverse section through middle of upper arm.

1. Triceps brachii.
2. Radial nerve and profunda brachii artery (musculo-spiral nerve and superior profunda artery).
3. Cephalic vein.
4. Brachio-radialis (supinator longus).
5. Brachialis.
6. Brachialis.
7. Biceps humeri.
8. Brachial artery.
9. Median nerve.
10. Medial cutaneous nerve of the arm (internal cutaneous nerve).
11. Ulnar nerve.
12. Basilic vein.
13. Musculo-cutaneous nerve.
14. Triceps.
15. Humerus.

sected upwards on the inner side, comprising all the muscles, the subscapularis being detached from the small tuberosity of the humerus. The limb is now medially rotated, and a lateral flap dissected outwards in a similar manner, the supra- and infraspinatus and teres minor muscles being detached from the great tuberosity of the humerus. The remaining part of the capsule is divided behind, and a cut made distally and laterally behind the bone until the limb is freed from its connections with the trunk.

As the posterior part of the section is being made the flaps are well retracted; and if the brachial artery has not been ligatured at an earlier stage, it is now grasped by an assistant or seized with pressure forceps.

The brachial artery is tied, together with any bleeding points becoming visible, as the pressure on the subclavian artery is relaxed, and the large nerve trunks dissected upwards for one inch and cut across.

The entire wound is sponged dry, and the margins of the flaps united by the insertion of sutures. A drainage tube may be placed in one angle of the wound if there is much oozing, and removed at the expiration of twenty-four to thirty hours.

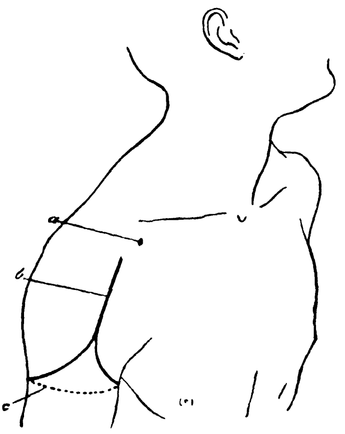

FIG. 497.—Amputation at the shoulder-joint. Position of lateral incision.

a. Coracoid process.
b. Vertical part of incision.
c. Circular part of incision.

In some cases it may be advisable, owing to the condition of the tissues in the neighbourhood of the shoulder-joint, to make a U-shaped flap, consisting chiefly of the deltoid muscle and the tissues superficial to it. The preceding operation, however, is generally the more suitable one, and can most often be employed with good results.

Amputation of the upper extremity.—Amputation of the upper extremity comprises removal of the arm, including the scapula and the lateral two-thirds of the clavicle. The medial third of the clavicle is not removed usually unless the bone is extensively implicated in a malignant growth.

Indications.—(*a*) Severe injuries involving destruction of the entire upper extremity, such as gun-shot wounds or machinery accidents.

(*b*) Malignant disease in the region of the shoulder-joint involving the scapula or clavicle, with infiltration of the lymph glands in the axilla.

(*c*) Some cases of extensive tuberculous disease extending from the shoulder-joint into the adjacent tissues.

(*d*) Some cases of carcinoma of the breast in which the contents of the axilla are extensively involved.

Special instruments.—Bone forceps, periosteal elevator, small saw, lion forceps.

Position.—The position of the patient, operator, and assistants varies during the operation. In the first stage the patient is placed in the dorsal position, with the affected shoulder projecting somewhat beyond the edge of the operation table. A sandbag is placed between the scapulæ, so as to raise the diseased shoulder. The arm lies by the side. The surgeon stands on the outer side of the affected limb, with an assistant on each side of him.

In the second stage the arm is drawn away from the body, and the surgeon stands between the limb and the trunk.

In the third stage the arm is carried over the chest towards the opposite side, and the surgeon stands on the outer side of the limb.

Operation.—The operation itself may be conveniently divided into three stages—(*a*) Incision over and removal of the middle third of the clavicle, and ligature of the subclavian vessels in the third part of their course; (*b*) formation of the anterior flap, and division of the brachial plexus; (*c*) formation of the posterior flap, ligature of the posterior scapular and transverse scapular arteries, and detachment of the limb.

FIRST STAGE.—*Incision over and removal of the middle third of the clavicle, and ligature of the subclavian vessels, in the third part of their course.*—An incision is made commencing over the junction of the medial with the intermediate fourth of the clavicle and extending along this bone to just beyond the acromio-clavicular articulation. This divides all the soft tissues, including the periosteum, down to the bone. With a periosteal elevator the periosteum is detached from the clavicle after it has been divided in a circular manner by the knife at the inner part of the wound. The soft parts are held aside with retractors, and the bone sawn through with a small saw at the junction of its medial and intermediate thirds. The lateral portion of the bone is drawn laterally with lion forceps, and the soft tissues attached to its deep aspect separated. The bone is again sawn through at the junction of the middle and lateral thirds, and the separated segment removed. The subclavius muscle will now be seen lying in the bottom of the wound. It is cut through just beyond its attachment to the cartilage of the first rib, and turned aside, thus exposing the subclavian artery and vein. At the lateral border of the first rib these structures are separated from their connections with the surrounding tissues, and a double ligature passed around each. These ligatures are tied so as to leave about ¾ inch of the vessel between them ; the vessels are then divided. The artery is ligatured and cut across before the veins, so that the limb may not remain engorged with blood.

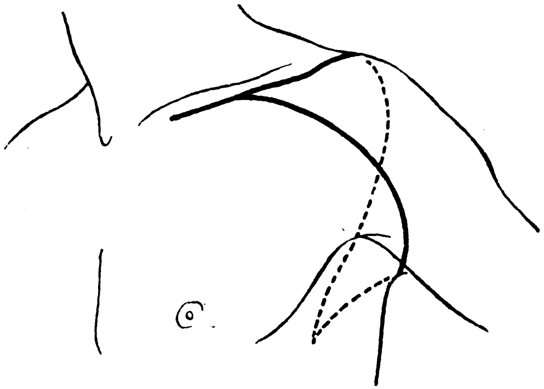

Fig. 498.—Removal of upper extremity, including the scapula. Position of external incisions, the dotted lines represent the posterior incisions.

Second Stage.—*Formation of the anterior flap and division of the brachial plexus.*—The patient is drawn farther over the edge of the table, the arm pulled away from the side, and the surgeon takes up his position between the limb and the trunk.

A curved incision is then made, which commences at the middle of the clavicle, and extends distally and laterally to the lateral side of the coracoid process, and then over the anterior part of the deltoid muscle to the anterior fold of the axilla. It then crosses the arm at its junction with the axilla to the posterior fold, and finally distally and backwards to the inferior angle of the scapula. The limb is raised and rotated by an assistant as this incision is being made.

The incision first divides skin and fasciæ, a flap being dissected up, and the pectoral muscles cut through. The flap thus separated is retracted to the medial side, so as to expose the brachial plexus, the cords of which are cut through just beyond the lateral margin of the first rib. At the distal part of the incision the latissimus dorsi is divided a short distance from its attachment to the humerus.

THIRD STAGE.—*Formation of the posterior flap, ligature of the posterior scapular and transverse scapular arteries, and detachment of the limb.*—The limb is drawn across the chest by an assistant, so as to expose the posterior aspect of the scapular region.

An incision is made commencing over the acromio-clavicular articulation at the lateral extremity of the first incision, and extending distally and backwards over the spine of the scapula to the lower extremity of the second incision. This divides skin and fasciæ only. The flap is dissected backwards, the trapezius muscle being cut through just beyond its insertion into the clavicle and scapula, until the superior angle and vertebral border of the scapula are exposed.

The limb is now allowed to hang down by the side, the anterior and posterior flaps are retracted, and then by a series of cuts the muscles which are attached to the vertebral border, the superior angle, and the superior border (rhomboideus major and minor, levator scapulæ, omo-hyoid, and serratus anterior) are cut through, and the arm removed. The transverse scapular (supra scapular) artery is secured as it passes over the scapular notch, and the posterior scapular at the superior angle of the scapula. All bleeding points are picked up with pressure forceps, and ligatures applied.

Closure of external wound.—The margins of the flaps are brought together and fixed in position by the insertion of a series of interrupted sutures. The lower angle of the wound should be left open, and a drainage tube inserted, which should be removed at the expiration of twenty-four to thirty-six hours.

Dressings are applied, and fixed in position by firm bandaging.

AMPUTATIONS IN THE LOWER EXTREMITY

Whenever the surgeon has in contemplation removal of a portion of the lower extremity, either on account of injury or disease, he should bear in mind that the main function in man of the lower extremities is locomotion, and that all operations should leave the remains of the limb in the best condition for performing this function. Thus, when dealing with removal of the toes or parts of them, especial care must be taken not to leave any irregular or sharp prominence of bone which afterwards may easily cause abrasions of the overlying skin, and hence become the seat of commencement of inflammatory affections ; and also, when removing a portion of the foot, the main flap, if possible, should always be taken from the plantar aspect, on account of the thicker covering of epithelium, and its especial fitness for coming in contact with the ground in walking. When the skin on the dorsal aspect of the foot is utilised for the main flap, and hence is made to form part of the covering of the sole, it is very unsatisfactory owing to its unsuitability for continued pressure. For those patients for whom it is decided that an amputation through the limb above the ankle is necessary, the operator must have for his goal, in addition to removing the diseased or injured tissues, the creation of a stump which shall have been so designed that it permits the instrument maker to fit an artificial limb which shall be the most suitable for the position in life in which the patient is placed, and also shall be useful and painless.

Amputation of the toes.—It is advisable as far as possible, in performing an amputation, partial or complete, of any of the toes, that the flaps should be so fashioned that the scar is not placed on the plantar aspect.

An amputation of a toe may be performed either through the terminal interphalangeal or the metatarso-phalangeal joints, in most cases the latter being the better operation. Amputations through other parts of the toes are as a general rule not advisable, since the stump which is left is of no practical use, and often becomes a source of irritation.

When undertaking operations for the removal of the toes, on account of congenital deformity, injury, or disease, it is not necessary to adhere to the rule which was recommended in connection with amputations of the fingers—to save as much of the digit as possible—since, in the majority of patients, better functional results are obtained by removing an entire toe than by removing a portion of it. An exception to this is the case when inflammatory or tuberculous affections of the great toe are being dealt with, since here better functional results are obtained by resection of the diseased portions of the toe than by removal of the entire digit. Removal of an entire toe, with the exception just mentioned, does not seriously impair the usefulness of the foot for locomotion ; hence it is usually preferable to excise the toe, instead of adopting a conservative method and removing only the diseased or deformed portion. This advice especially applies in the case of " hammer toes," where undoubtedly better results are secured by amputation at the metatarso-phalangeal joint, than by excision of the deformed articulation.

Another exception should also be noted in connection with the surgery of the toes—as regards the treatment of dry gangrene. Here it is better to wait until the line of demarcation between the dead and living tissues has become apparent, and then to remove the dead portion of the digit at this line. The reason for this recommendation is, that if the ordinary rule of removal of the entire toe be carried out, it usually happens that gangrene of the flaps and incised surfaces follows.

Amputation of the distal phalanx—(*a*) **Of the great toe.**—The best result is obtained by making a large plantar flap.

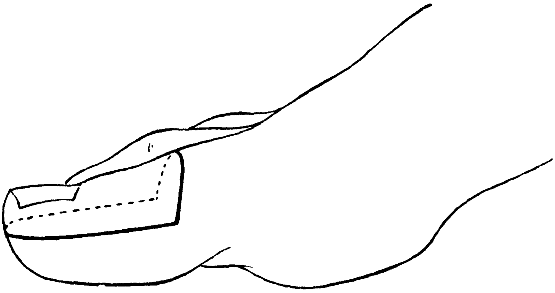

FIG. 499.—Amputation of distal phalanx of great toe. Skin incision.

Operation.—An incision is made commencing on the medial aspect of the toe just beyond the line of the articulation, passing distally nearly to the extremity, then transversely across the pulp, and up along the lateral side to a point immediately distal to the line of the joint and opposite its commencement. The toe is fully extended by an assistant, whilst the surgeon dissects back the flap until the line of the joint is reached, the plantar ligament being divided at this stage. The surgeon now takes hold of the toe, fully flexes it, and makes an incision across its dorsal aspect. The joint is opened from above, the extensor hallucis longus tendon divided, and the lateral ligaments cut through from without inwards. The toe is now separated from its connections, and can be removed (Figs. 499–501).

The digital arteries are picked up with pressure forceps and ligatured. The extensor and flexor tendons are fixed by several points of suture either to one another or to the periosteum and ligaments. The plantar flap is brought over the end of the first phalanx, and the margins of the incision united by the insertion of sutures.

(*b*) **Of one of the four lateral toes.**—This operation differs in no essential respect from the preceding one.

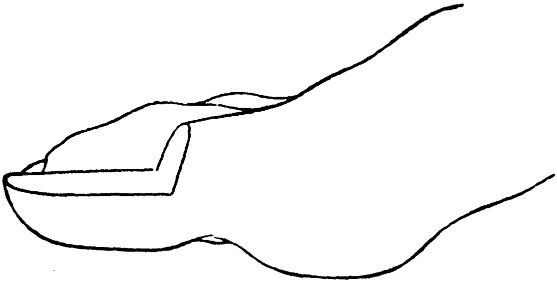

FIG. 500.—Appearance of toe when phalanx has been removed.

Amputation through a metatarso-phalangeal joint—(*a*) **Of the great toe.**—On account of the large size of the head of the metatarsal bone, it is strongly recommended that it should be removed in all cases. When this is being done, the bone should be sawn obliquely, so as to remove more on the lateral than on the medial aspect. Care also must be taken to make the flaps sufficiently large to afford a complete covering for the sawn surface.

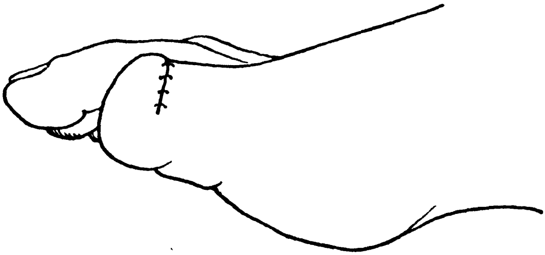

FIG. 501.—Appearance of toe when operation is completed.

Operation.—An incision is made commencing just proximal to the head of the first metatarsal bone, extending distally to below the line of the joint, then around the plantar aspect of the toe, and upwards upon the fibular side, and across the dorsum until the vertical incision is reached (Fig. 502). It is usually advisable to cut the tissues on the plantar aspect somewhat longer than on the dorsum, and the incision may reach as low as the interphalangeal joint. The soft tissues are divided down to the bone, and dissected up, the sesamoid bones being left in connection with the head of the metatarsal bone. The flaps are retracted, the tendons cut through, and the joint opened from above. The ligaments are then divided, and the toe removed.

With a metacarpal saw the head of the bone is removed, the saw cut being made in an oblique direction, so as to remove more from the lateral aspect, and so avoid leaving a large prominence. The sesamoid bone also should be removed.

The digital vessels are ligatured, the tendons fixed by sutures, and the flaps brought together, and fixed in apposition by sutures.

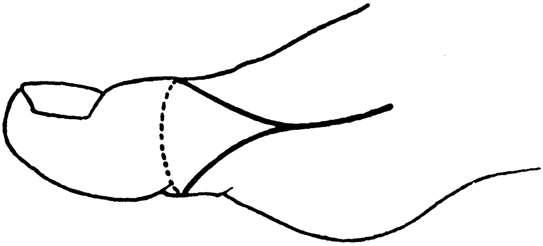

FIG. 502.—Amputation of great toe through the metatarso-phalangeal joint. Skin incision.

(*b*) **Of the little toe.**—An incision is made commencing just proximal to the head of the fifth metatarsal bone, and somewhat nearer the dorsal than the plantar aspect. This passes vertically distally to a point well below the line of the joint, and then around the toe in an oval-shaped manner until it joins the vertical part of the incision. The soft tissues, including the tendons, are divided, the flaps dissected up, retracted by an assistant, and disarticulation effected by cutting through the ligaments from without medially. The head of the metatarsal bone is now removed, either with a saw or cutting bone forceps.

The digital vessels are ligatured as before, the tendons fixed by sutures, and the flaps brought into apposition, and sutured.

(*c*) **Of the second, third, or fourth toes.**—The toes on each side of the one to be removed are held aside with aseptic gauze by an assistant. The surgeon grasps the toe in his left hand, and makes a racket-shaped incision, commencing over the dorsal aspect of the corresponding metatarsal bone, extending distally to a point just proximal to the metatarso-phalangeal joint, and then around the toe at the level of the web. The flaps so marked out are dissected up, the edge of the knife being kept towards the bone, and the extensor tendons cut through.

The joint is opened from above, disarticulation completed, and the digit removed. The head of the metatarsal bone should be removed in nearly all cases.

The digital vessels are ligatured, the tendons fixed by sutures, and the margins of the flaps are brought together, and fixed in apposition with sutures.

Amputation of a toe together with its metatarsal bone—(*a*) **The great toe and metatarsal bone.**—A point is selected on the medial side of the first cuneiform bone somewhat nearer the dorsal than the plantar aspect. An incision is made commencing at this point, and extending vertically along the shaft of the metatarsal bone to a point nearly opposite the metatarso-phalangeal joint, and then around the toe in an oval-shaped manner, as in disarticulation at the metatarso-phalangeal joint. The soft tissues, including the tendons, are divided down to the bone, and the flaps dissected up. These are held aside by an assistant, and the toe forcibly pulled towards the medial side by the surgeon, and freed from its connections with the soft tissues by a few strokes of the knife, care being taken to avoid the dorsalis pedis artery as it passes through the proximal part of the first intermetatarsal space. The joint is then opened from the dorsal aspect, the ligament cut through, and the toe removed.

The digital vessels on the margins of the flaps are picked up with pressure forceps and ligatured, and the tendons fixed with sutures. The margins of the flaps are brought together, and fixed in apposition by the insertion of sutures.

(*b*) **The little toe and metatarsal bone.**—The prominent base of the fifth metatarsal bone projects backwards for some distance beyond the line of the tarso-metatarsal joint.

The apex of the tuberosity of the fifth metatarsal bone is felt for on the lateral margin of the foot, and an incision made commencing at this point, and extending distally in a vertical direction nearly to the metatarso-phalangeal joint, then round the toe in an oval-shaped manner, as in the preceding operation. The soft tissues are divided down to the bone, and the flaps dissected up, and retracted by an assistant. The toe is then forcibly pulled towards the fibular side, and the connections of the metatarsal bone with the soft tissues cut through. The joint is opened from above, the ligaments divided, and the toe removed.

The digital vessels are ligatured, and divided tendons fixed, and the flaps brought together and sutured.

(*c*) **The second, third, or fourth toe and metatarsal bone.**—The line of the metatarso-phalangeal joint is defined, and an incision commenced on the dorsal aspect of the base of the metatarsal bone of the toe to be removed. This extends downwards in a vertical direction to a point just proximal to the head of the metatarsal bone, and then round the plantar aspect of the toe in an oval-shaped manner. The soft tissues are divided down to the bone, and the flaps dissected up, care being taken to keep the edge of the knife always turned towards the bone.

The toe is then forcibly extended, whilst the surgeon cuts through the interosseous muscles and other soft structures with which it is connected. The joint is opened from the dorsal surface, the lateral and plantar ligaments cut through, and the toe taken away.

The blood vessels are ligatured, the tendons sutured, and the flaps brought into apposition, and sutured.

Amputation through the metatarsus.—This operation is rendered necessary in some cases of severe mutilation of the distal part of the foot. No exact direction can be given for its performance, since the position of the skin incisions depends upon the amount of sound tissue available.

In all cases, however, it is advisable, if possible, to make the plantar flap larger than the dorsal. The metatarsal bones, when exposed after the flaps have been dissected back, are sawn through immediately proximal to the limits of the injury. The various blood vessels are picked up with artery forceps and ligatured, the divided tendons fixed by sutures, and the flaps adjusted and fixed in position by the insertion of sutures.

Amputation through the tarso-metatarsal joint.—*Position.*—The patient is placed in the dorsal position, with the affected foot projecting beyond the end of the operation table. The surgeon stands in front of the foot to be operated upon, facing the sole, and his assistant opposite to him.

Operation.—Two points are defined, one the prominence of the base of the metatarsal bone on the lateral side of the foot, the other opposite the tarso-metatarsal articulation of the great toe, or the point of insertion of the tibialis anterior. When this cannot be readily felt, a point is taken on the medial margin of the foot one inch in front of the prominence caused by the tuberosity of the navicular (scaphoid).

The foot is grasped by the left hand of the operator, and an incision made in a slightly curved direction, with the convexity towards the toes, across the dorsum, extending between the two selected points. This incision divides all the soft tissues down to the bones. The foot is now fully flexed, and held by an assistant, whilst the surgeon makes the plantar incision. This commences on the lateral side of the foot at the extremity of the first incision, extends along the lateral side as far as the head of the metatarsal bone, then obliquely across the sole and up the medial side of the foot, until the other extremity of the dorsal incision is reached. This incision should be so made that the flap is a little longer on the medial than on the lateral side, so as to allow a complete covering for the prominent first cuneiform bone.

The surgeon then takes hold of the edge of the flap thus marked out with the finger and thumb of his left hand, and dissects up the flap, which should comprise all the tissues of the sole down to the bones.

The flap is dissected backwards as far as the line of the tarso-metatarsal articulation. The foot is then forcibly depressed, and the three lateral metatarsal joints opened from the dorsal aspect.

The articulation between the first cuneiform and the base of the first metatarsal bone is opened from the medial side, and then the lateral aspects of the base of the second metatarsal are cleared by cutting towards the tarsus.

The joint between the second metatarsal and the second cuneiform bone is opened from above, the foot further depressed, and the remaining soft tissues cut through. The foot can now be removed.

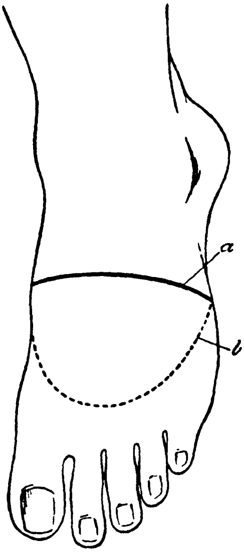

FIG. 503.—Amputation of the foot through the tarso-metatarsal joint. Skin incisions.

a. Dorsal incision.
b. Plantar incision.

The dorsalis pedis artery is secured as it lies in the dorsal and medial portion of the wound, and the lateral and medial plantar arteries in the lateral and medial parts of the sole flap, together with any other vessels from which hæmorrhage is taking place.

The plantar flap is now brought over the extremity of the stump, and its margins united to those of the dorsal flap by the insertion of a series of interrupted sutures, special care being taken to secure exact apposition on the inner side.

This operation of disarticulation of all the tarso-metatarsal joints is often known as " Lisfranc's amputation."

The operation of amputation through the tarso-metatarsal joint is now rarely performed ; when an amputation is necessary in this region, the more usual practice is to saw through the tarsus on the proximal side of the injury, or disease, and to effect a separation in this way. This is rendered possible on account of the lessened dangers from septic osteomyelitis after division of bones, owing to modern methods of treatment.

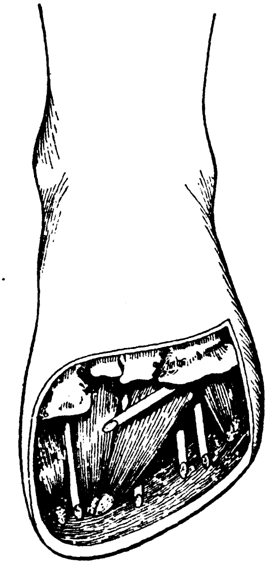

FIG. 504.—Amputation of the foot of the tarso-metatarsal joint. Appearance of foot when distal portion has been removed.

Amputation through the tarso-metatarsal joints, with removal of the projecting portion of the first cuneiform.—This operation is similar to the preceding, but instead of performing disarticulation through the joint between the base of the metatarsal bone of the great toe and the first cuneiform, the projecting part of the latter is sawn through. This modification is usually known as " Hey's amputation."

Amputation through the first, third, fourth, and fifth tarso-metatarsal joints, with sawing through of the shaft of the second metatarsal bone below its base.—This operation is similar to the above, with the exception that the shaft of the second metatarsal bone is sawn through in the line of the adjacent articulations. This has been called " Skey's amputation."

Amputation through the transverse or mid-tarsal joint—talo-navicular-calcaneo-cuboid joint (" Chopart's operation ").—In this operation the portion of the foot distal to the mid-tarsal joint is removed, the only bones of the tarsus left behind being the talus and calcaneus.

There is a considerable divergence of opinion amongst surgeons as to the value of the results obtained by amputation through the mid-tarsal joint, or "Chopart's operation," and the usefulness of the limb afterwards; in fact, some have given up the performance of the operation, on account of the retraction of the heel and the consequent painful and useless stump, and have recommended in its place either amputation at the junction of the distal and middle thirds of the leg, or at the ankle-joint. The cause of retraction of the heel appears to have been due to non-fixation of the cut tendons on the dorsal aspect of the foot, and traction on the tendo calcaneus by the somewhat unopposed calf muscles. If, after the foot has been removed through the mid-tarsal joint, the flexor and extensor tendons are joined and fixed together by careful suturing over the articular ends of the bones, and also to the cut ligaments and periosteum, this retraction does not occur in the majority of patients. The stump of the limb should be fixed and held in proper position during the process of healing by the application of a well-moulded poroplastic splint. When retraction of the heel has been allowed to occur, it has been treated by tenotomy of the tendo calcaneus, but, as far as my observation has gone, with unsatisfactory results. When healing has taken place, and provided that the above-mentioned difficulties have been overcome, the resulting stump will be found to be a very satisfactory one, since the movements at the ankle-joint are retained.

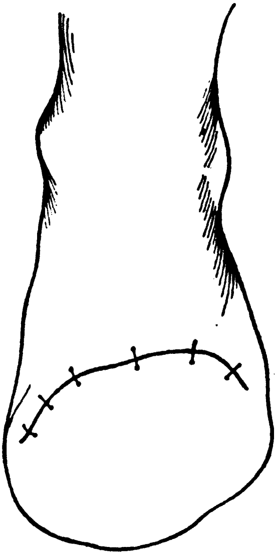

FIG. 505.—Amputation of the foot of the tarso-metatarsal joint. Appearance of foot when flaps have been sutured.

Position.—The positions of patient, surgeon, and assistant are similar to those for amputation through the tarso-metatarsal joint.

Operation.—Two points are defined—one on the medial aspect of the foot immediately behind the tuberosity of the navicular, the other on the lateral side, midway between the apex of the lateral malleolus and the prominence of the base of the fifth metatarsal bone.

An incision is made which extends between these two points, and crosses the dorsum in a somewhat curved direction, the convexity being towards the toes. This incision crosses the bases of the metatarsal bones just in front of the tarso-metatarsal joints.

The foot is flexed and held in this position by the assistant, whilst the operator makes the plantar incision. This commences (in the case of the right foot) at the lateral extremity of the dorsal incision, and extends along the lateral side of the foot as far as the middle of the metatarsal bone of the little toe, then crosses the sole opposite the middle of the other metatarsal bones to the medial side, and then along the medial margin of the foot to the medial extremity of the dorsal incision. This plantar flap should be made a little longer on the medial side.

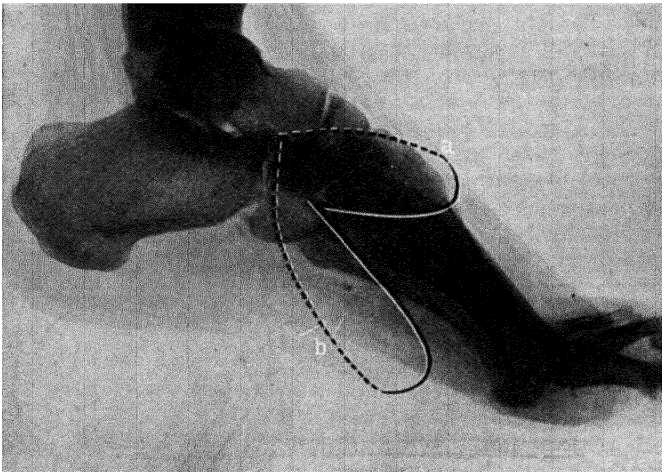

FIG. 506.—Amputation of the foot through the mid-tarsal joint. Skin incisions.

a. Dorsal part. | *b.* Plantar part.

The plantar flap is dissected up, and made to include all the soft tissues down to the bones, until the transverse tarsal joint is reached. The operator now grasps the distal part of the foot, extends it, and divides the ligaments on the dorsal aspect of the transverse tarsal joint. Care must be taken in this part of the operation not to leave the navicular bone behind. This can be avoided by noting the convexity of the head of the talus (astragalus), and the position of the tuberosity of the navicular (scaphoid).

The foot is farther depressed, the interosseous and plantar ligaments divided, and any other connections severed. It can then be removed.

The dorsalis pedis artery is secured in the dorsal flap, and in the plantar the lateral and medial plantar arteries. Some branches of the metatarsal artery may be found also in the dorsal flap and digital arteries in the plantar. These are picked up with artery forceps and ligatured.

All hæmorrhage having been arrested, the ends of the divided flexor and extensor tendons are approximated over the articular surfaces of the talus (astragalus, O.T.) and calcaneus, and fixed together by sutures; and, in addition, these tendons are fixed to the cut ligaments and the periosteum; and, finally, the plantar flap is brought over the extremity of the stump, and its margins approximated to those of the dorsal, and fixed in position by the insertion of a series of interrupted sutures (Fig. 508).

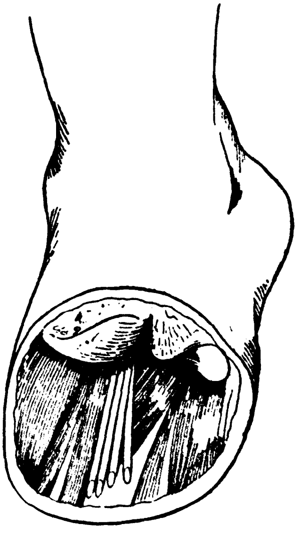

FIG. 507.—Amputation of the foot through the mid-tarsal joint. Appearance of foot when distal portion has been removed.

A moulded poroplastic or gutta-percha splint is then applied, and firmly fixed by bandages. This is kept on until the wounds have entirely healed, and serves to prevent retraction at the heel.

Subtaloid (subastragaloid) amputation of the foot.—Several varieties of this operation have been described. The following appears to give rise to the best results, and to be moderately easy in its performance. It is in reality a modification of the oval or elliptical method.

Position.—The patient is placed in the dorsal posture, with the affected foot projecting for a short distance beyond the lower end of the operation table. The surgeon stands at the right side of the foot, and his assistant opposite to him.

Operation.—The leg is slightly flexed at the knee, and the foot turned on its medial aspect by the assistant. A point is then taken over the proximal margin of the lateral tuberosity of the calcaneus at the insertion of the tendo calcaneus, and from this an incision is commenced which extends forwards to a point a short distance posterior to the prominence of the base of the fifth metatarsal bone. This incision is parallel to the lateral margin of the foot, and a little more than one inch distal to the apex of the external malleolus.

It is now carried across the dorsum of the foot in a curved direction, the convexity looking towards the distal and lateral part of the foot, until the medial side is reached, at a point opposite the middle of the medial aspect of the articulation, between the first cuneiform bone and the base of the first metatarsal.

The foot is flexed, and the incision carried across the sole until it joins the first cut opposite the apex of the lateral malleolus.

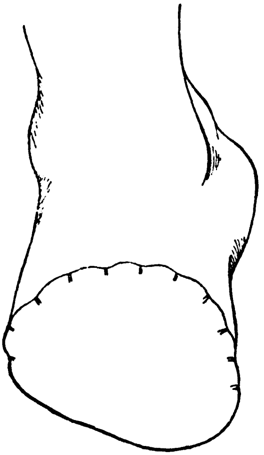

FIG. 508.—Amputation of the foot through the mid-tarsal joint. Appearance of foot when flaps have been approximated and sutured.

The skin and fasciæ are cut through first, and the skin allowed to retract for a short distance. Then, by a second sweep of the knife, all the soft tissues down to the bones are divided.

The dorsal flap is dissected up for a sufficient distance, the tendo calcaneus divided at the posterior part of the incision just proximal to its insertion into the calcaneus and the posterior part of the talo-calcanean joint opened from its lateral aspect by dividing the ligaments with the knife.

The blade of the knife is carried forwards between the distal aspect of the talus (astragalus, O.T.) and the proximal surface of the calcaneus so as to divide the ligaments which fix the two bones together. The most important of these is the strong interosseous ligament. Any tendons on the lateral side, which have not been divided at the second sweep of the knife, are cut through along with the ligaments.

The foot is firmly twisted medially, and by a series of short cuts with the knife the medial and distal aspects of the calcaneus are freed from their connections with the soft tissues. In this dissection the edge of the knife must be kept continually towards the bone, so as to avoid injury to the blood vessels, especially those which lie in the concavity on the internal aspect.

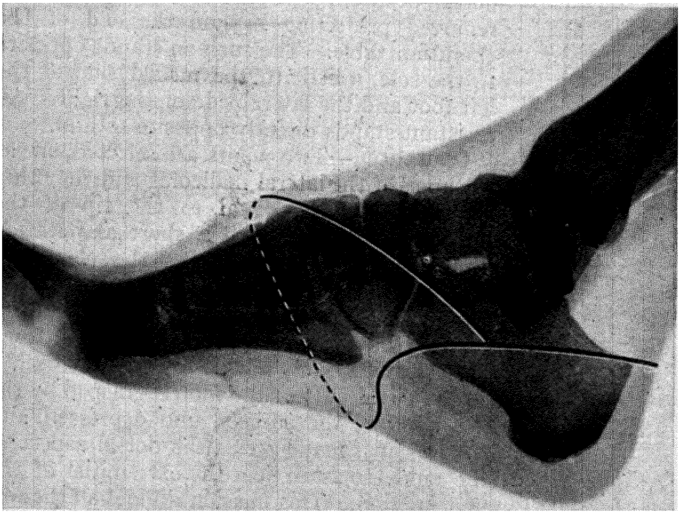

Fig. 509.—Sub-taloid (Sub-astragaloid) amputation of the foot. Skin incision.

The foot is still more twisted, and the remaining soft structures cut through. The foot can then be removed.

In the dorsal flap, branches of the tarsal and metatarsal arteries, and of the anterior and posterior peroneal arteries, and internally the dorsalis pedis artery, will be found to be cut across, and require ligature. In the plantar flap the cut ends of the medial and lateral plantar arteries require ligature.

The hæmorrhage having been arrested, the cut tendons are fixed by sutures, the margins of the dorsal and plantar flaps are brought into exact apposition, and fixed by the insertion of a series of interrupted sutures.

This operation does not yield a very satisfactory stump, and, in my opinion, it is often better to perform an amputation through the ankle-joint.

Amputation of the foot through the ankle-joint by the formation of a heel-flap, and removal of the distal extremities of the tibia and fibula ("Syme's operation").

Position.—The patient is placed in the dorsal position, with the foot which is to be removed projecting beyond the end of the operation table. The surgeon stands opposite to the sole, a little to the medial side of the left foot and the lateral side of the right. An assistant stands directly opposite to him.

Operation.—Two points are selected, one at the apex of the lateral malleolus and the other a finger's-breadth distal to the tip of the medial malleolus. With a short amputation knife an incision is made across the sole, which joins these two points and divides all the soft tissues down to the calcaneus. This incision crosses the plantar aspect not quite transversely, but sloping a little towards the heel.

FIG. 510.—Amputation of the foot. Short amputation knife.

The distal part of the foot is grasped by the left hand of the surgeon and depressed, and then a cut is made across the dorsal aspect of the ankle so as to join the extremities of the first incision. This incision divides all the soft tissues (skin, fasciæ, tendons, and vessels) down to the anterior surface of the joint. The anterior ligament is then divided and the joint cavity opened. The foot is further depressed, and the collateral (internal and external lateral) ligaments severed with the knife. This can be aided by twisting the foot from side to side. The posterior ligament of the joint is now cut through, and the proximal non-articular surface of the calcaneus exposed, together with the tendo-calcaneus where it is inserted into this bone.

The foot is still more depressed, the tendo-calcaneus divided, and then all the soft tissues on the distal and lateral aspects of the calcaneus separated from their connections with the bone by a series of short sweeps with the knife. Care must be taken during the separation of this heel-flap to keep the edge of the knife against the bone, otherwise the flap will be "buttonholed," or the posterior tibial artery will be wounded immediately below the medial malleolus—an accident which is to be avoided, since it diminishes considerably the blood supply of the sole flap.

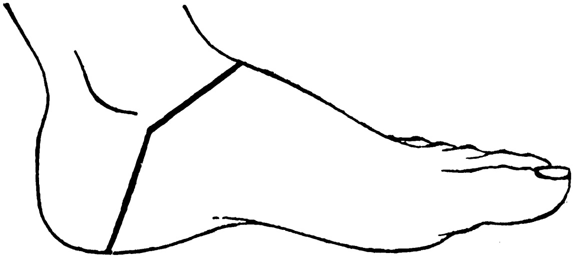

FIG. 511.—Amputation of the foot at the ankle-joint. Incision in "Syme's operation."

The foot is now removed, and the bases of the flaps, where they are close to the bone, are dissected proximally for about ½ inch, so as to lay bare the distal ends of the tibia and fibula for a short distance.

A saw is now taken, and a thin plate of bone removed in a transverse direction. This piece of bone comprises the two malleoli, the inferior articular surface of the tibia, and a small portion of the cancellous extremities of both bones.

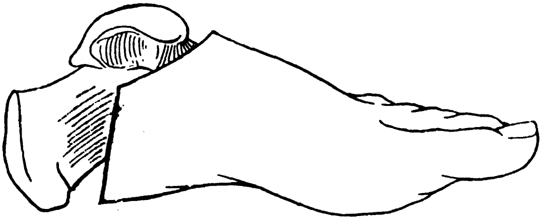

FIG. 512.—Amputation of the foot at the ankle-joint. Foot removed by Syme's method.

The bones are examined, and any carious or necrotic portions removed by scraping with a sharp spoon.

The dorsalis pedis artery is secured in the middle of the dorsal flap, and the medial and lateral plantar arteries at the medial margin of the heel-flap, together with any branches of the peroneal artery which may be causing hæmorrhage.

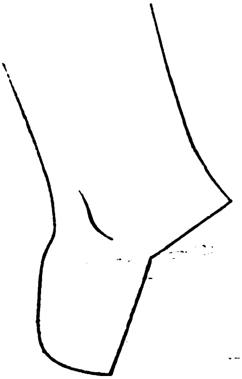

FIG. 513.—Amputation of foot at the ankle-joint. Appearance of limb when the foot has been removed by "Syme's operation."

All hæmorrhage having been arrested, any loose projecting pieces of tendons are cut away, and then the heel-flap is brought over the extremity of the stump, and fixed in position by the insertion of a number of interrupted salmon-gut sutures.

The operation described above is a modification of "Syme's operation."

The operation as described and practised by Syme himself was performed by dissecting up the heel-flap from below, and opening the ankle-joint in the later stages of the operation.

The modification as given above will be found to be easier of performance than the "original Syme," and to yield similar results.

When the condition of the tissues in the region of the ankle does not allow of the formation of a heel-flap such as that described above, and there is plenty of sound tissue on the medial side, the amputation may be performed by making a large medial flap, as is shown in Fig. 514 ("Roux's amputation").

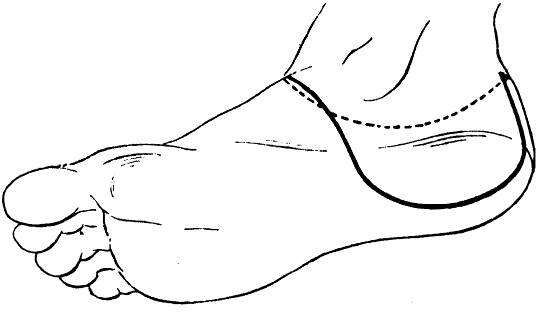

FIG. 514.—Amputation of the foot. Position and shape of medial flap ("Roux's amputation").

Amputation at the ankle-joint, in which a portion of the calcaneus is left behind and fixed to the distal end of the tibia.—There are several modifications of this operation, which depend upon the manner in which the calcaneus and the tibia are sawn.

The early stages of the operation are similar to those described in connection with "Syme's amputation," with the exception that the sole flap is made a little longer, the incision in these cases usually crossing the sole at right angles to the axis of the foot.

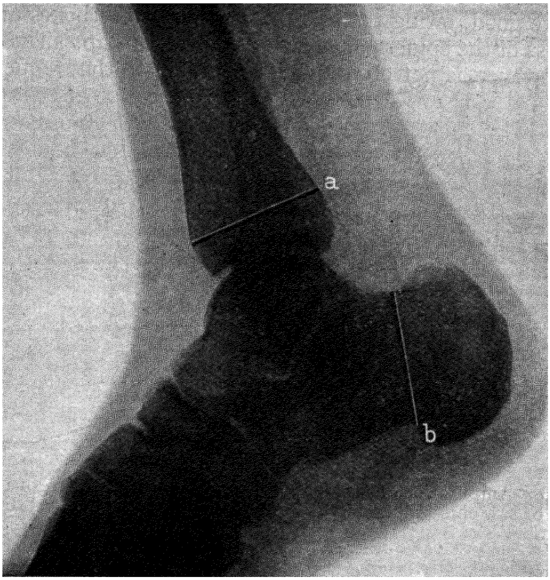

Fig. 515.—Amputation of the foot. Lines of saw cuts in "Pirogoff's amputation."

a. Tibia and fibula. | *b* Calcaneus (os calcis).

Fig. 515 shows the method of sawing the bones in "Pirogoff's operation," Fig. 516 in "Sédillot and Gunther's methods," and Fig. 517 the procedure recommended by Le Fort.

Gordon Watson has further improved the trans-calcanean operation of Pirogoff. He shapes the calcaneus in such a manner that it fits in the lower ends of the tibia and fibula after they have been prepared by gouging away their cartilage-clad surfaces. This operation is especially applicable for cases of congenital origin, and appears to give very good results.

When the bones have been sawn according to one or other of the methods illustrated in Figs. 515, 516, 517, and the hæmorrhage from the divided blood vessels arrested, the two sawn bony surfaces are brought into exact approximation, and then fixed by sutures, either of silver wire or strong chromicised catgut. It is advisable also to fix the divided tendons to one another, or to the periosteum and ligaments. Next, the cutaneo-fascial flaps are co-apted, and their margins carefully sutured.

The functional results which are obtainable from these operations are good, owing to the firm fixation of the bones and the thickness of the epidermal covering of the heel-flap. The operation, however, is not often available, owing to the frequency of involvement by disease of the calcaneus in patients in whom amputation at the ankle-joint is considered necessary. The operation finds its most useful application after severe injuries to the greater part of the foot.

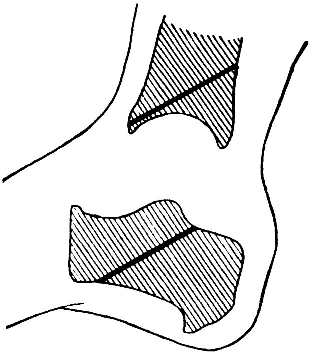

FIG. 516.—Amputation of the foot. Lines of saw cuts in "Sédillot's operation."

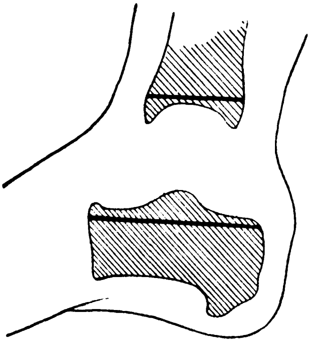

FIG. 517.—Amputation of the foot. Lines of saw cuts in "Le Fort's operation."

Amputations through the leg.—The occupation and wishes of the patient should always be taken into serious consideration before deciding upon the form of amputation which ought to be performed upon the leg. When it is desirable that the stump should be fitted up afterwards with a "peg-leg," a short limb is absolutely essential, and it is recommended that the section of the bone be carried out at, or immediately below, the level of the tubercle of the tibia. Before the time when instrument makers were able to make comparatively useful artificial limbs, an amputation was generally carried out through this point, owing to the ease with which a "peg-leg" could be fitted. On this account, an amputation through the proximal third of the leg, immediately below the tibial tubercle, was called an operation at "the seat of election." An artificial limb, which shall be useful for locomotion, and not liable to give rise to difficulties, can be fitted to the leg when an amputation has been carried out through the middle third, or the distal part of the proximal third. To ensure comfort and convenience, the stump below the level of the knee-joint ought not to be less than 3½ or 4 inches long. The most favourable seat of amputation in the leg, in patients in whom it is intended that a well-designed artificial limb shall be fitted, is the junction of the middle with the distal thirds or the distal part of the middle third. It must be remembered, however, that a sound stump, resulting from an amputation of the leg, anywhere between the junction of the distal and middle thirds and the level of the tuberosity of the tibia, can be fitted with a satisfactory, useful, and painless artificial limb. When amputations are performed through the distal third of the leg, very unsatisfactory stumps result, and satisfactory artificial limbs cannot be fitted. Removal of the leg, therefore, through the lower third is not recommended, but for purposes of students attending "courses of practical operative surgery on the dead body," some of the operations which in former times were considered desirable are given.

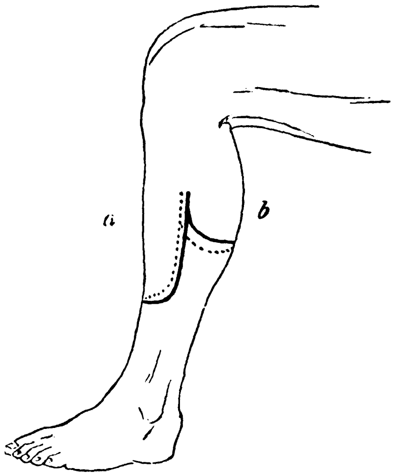

FIG. 518.—Amputation through the leg by a long anterior and a short posterior flap.

a. Anterior incision.
b. Posterior incision.

Amputations through the leg may be performed by—

(*a*) Antero-posterior flaps of unequal length.
(*b*) Lateral flaps.
(*c*) The elliptical method.

(*d*) The circular method.
(*e*) A long lateral flap.
(*f*) An anterior rectangular flap.

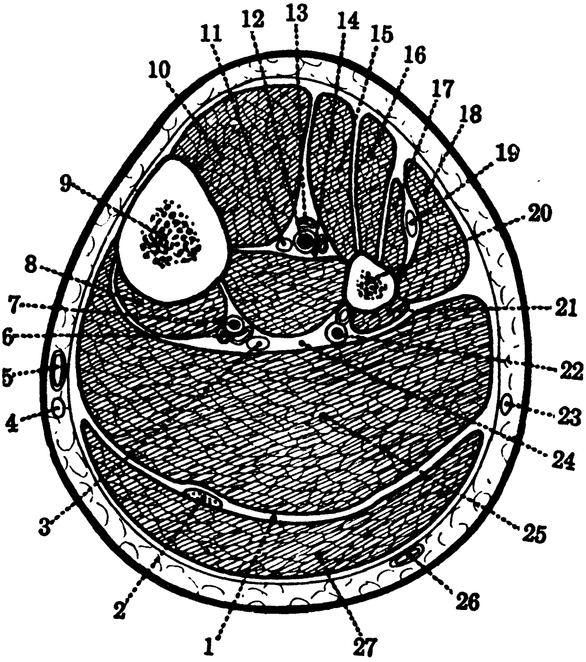

FIG. 519.—Transverse section through middle of leg, showing position of structures divided.

1. Fascia between soleus and gastrocnemius.
2. Plantaris.
3. Tibial nerve.
4. Saphenous nerve.
5. Saphenous vein.
6. Large tibial nerve.
7. Posterior tibial artery.
8. Flexor digitorum longus.
9. Tibia.
10. Tibialis anterior.
11. Deep peroneal nerve.
12. Anterior tibial artery.
13. Anterior tibial vein.
14. Interosseous membrane
15. Extensor hallucis longus.
16. Extensor digitorum longus.
17. Peronæus brevis.
18. Peronæus longus.
19. Common peroneal (external popliteal) nerve.
20. Fibula.
21. Flexor hallucis longus.
22. Peroneal artery and vein.
23. Sural nerve.
24. Deep transverse fascia.
25. Soleus.
26. Sural vein.
27. Gastrocnemius.

In the middle third, either the operations by antero-posterior flaps of unequal length, or by the elliptical method, or a long lateral muscular flap, may be made use of.

In the proximal third, lateral cutaneo-fascial flaps, with circular divisions of muscles, or a long lateral muscular flap, are the most suitable operations.

(*a*) *By antero-posterior flaps of unequal length.—Position.*—The patient is placed in the dorsal posture, with the affected limb projecting beyond the end of the table, and the opposite limb tied down out of the way. The surgeon stands on the outer side of the right limb and on the inner side of the left. One assistant grasps the foot, and manipulates it as required, whilst a second stands opposite to the operator.

Operation.—The longer flap may be situated on either the anterior or posterior aspect of the limb, usually the former, but this depends entirely on the condition of the tissues of the leg at the time of operation. The longer flap should be so fashioned that in width it measures half the circumference of the limb, and in length the diameter of the limb, at the level of the plane of section of the bone. The shorter flap should be about one half the length of the longer one.

The incisions are made, and the flaps dissected up. They should at first consist of skin and fasciæ alone, but at their base they should be made to include muscular tissue. Both flaps being dissected up, they are retracted by an assistant, and the soft tissues divided down to the bone for the entire circumference of the limb.

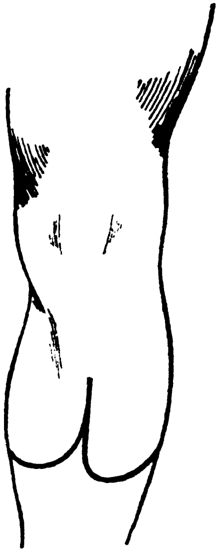

FIG. 520.—Amputation of leg by lateral flaps. Skin incisions.

The periosteum is dissected back for a short distance, and then the bones are sawn across, care being taken to complete the section of the fibula before that of the tibia. The sharp anterior border of the latter should be rounded off, as shown in Fig. 523.

When it is desired to fit an artificial limb, the fibula should be sawn ½ inch shorter than the tibia. This ensures a more conical, and therefore more useful, stump.

The anterior tibial, posterior tibial, and peroneal arteries are picked up with artery forceps and ligatured. Their relative positions are shown in Fig. 519. The large nerves are dissected proximally for one inch, and then divided. The muscles are then fixed by sutures, both to one another and to the deep fascia, and the periosteum sewn over the ends of the bones.

The flaps are now brought over the extremity of the stump, and their margins approximated, and fixed by the insertion of sutures.

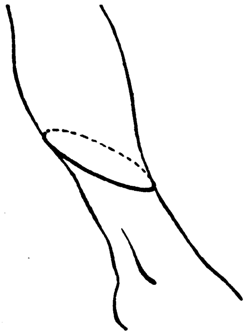

FIG. 521.—Amputation of leg by elliptical method. Position of skin incision.

(*b*) *By lateral flaps.*—A point is taken in the middle line of the anterior aspect of the limb at the level of the proposed plane of section of the bone, and a vertical incision is made distally from this point for 3 inches. The incision is then carried across the side of the limb in a slightly oblique direction to the middle of the calf behind, and then upwards to the level of the original incision. A similar flap is marked out on the opposite side. The two flaps are dissected up, and should consist only of skin, superficial and deep fascia.

About 1 or 1½ inches below the level at which the bones are to be divided the muscles are cut through in a circular direction by two or three circular sweeps of the knife. They are then dissected up for a short distance, the periosteum is divided and dissected up, and the bones sawn as before.

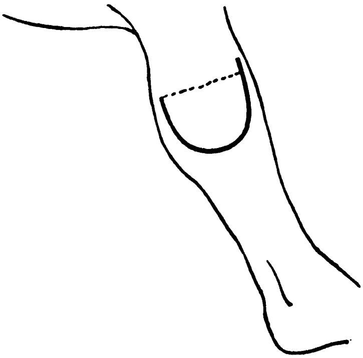

FIG. 522.—Amputation of leg by large lateral muscular flap ("Farabœuf's operation").

The dark line shows the position of the long lateral incision, and the dotted line that of the short medial incision.

The vessels are picked up and ligatured, the distal portions of the large nerves dissected free and excised, the periosteum and muscles sewn together, and the margins of the flaps united by sutures.

(*c*) *By the elliptical method.*—The distal extremity of the ellipse may be situated either on the anterior or the posterior aspect of the limb, usually on the anterior.

The incision first divides skin and fasciæ ; these are dissected up, the muscles cut through and dissected back, and the bones sawn across.

(*d*) *By the circular method.*—The circular method presents no special features.

(*e*) *By a long lateral flap.*—This operation is employed in the proximal half of the leg, a thick muscular flap being obtained from the lateral aspect of the limb.

A point is selected in the middle of the anterior aspect of the limb at the level of the proposed plane of section of the bone, and from this an incision is commenced which extends distally in a vertical direction for a distance equal to one-third of the circumference of the limb at the level at which the bone is to be divided. The incision is then carried round the lateral aspect of the limb in a gently curved direction to the middle of the calf, and then proximally to a point about one inch distal to the level at which it commenced.

The skin and fasciæ are divided for the entire length of the incision, and allowed to retract.

The limb is now turned laterally, and a second skin incision made from the posterior extremity of the first to a point 1½ inches distal to the proximal extremity of the anterior portion of the same incision. This second incision runs almost horizontally ; it should divide skin and fasciæ, which structures are allowed to retract.

The limb is then turned on to its medial aspect by an assistant, and the surgeon dissects up the large lateral flap which has been marked out, taking up all the soft tissues down to the bone. Care must be taken not to dissect up the flap too high, otherwise the anterior tibial artery which comes through the upper part of the interosseous membrane may be unintentionally severed. The anterior tibial artery should be divided at the distal extremity of the external muscular flap.

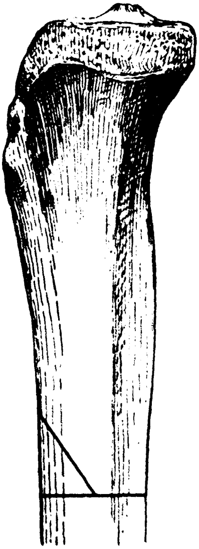

FIG. 523.—Amputation of leg. Method of rounding off anterior border of tibia.

The muscles of the short medial flap are then divided, and the flap dissected up in a manner similar to the preceding.

The periosteum and the interosseous membrane connecting the two bones are then cut through by a circular sweep of the knife, and in favourable cases the periosteum may be separated from the bones for a short distance. All the soft tissues, including the periosteum, are now retracted, and the bones sawn through. In sawing across the tibia it is advisable to remove first of all a small segment of the sharp anterior border before making the transverse section. The method of doing this is shown in Fig. 523.

The vessels are ligatured, the exposed portions of the large nerves excised, the periosteum brought over the ends of the bones and fixed by the insertion of one or two points of suture, and then the flaps are adjusted and sewn up.

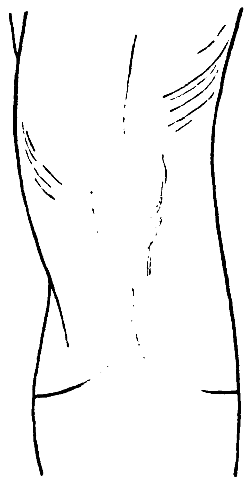

FIG. 524.—Amputation of leg through the knee-joint. Skin incisions. ("Stephen Smith's operation.")

This method of amputating gives a stump the distal extremity of which is well covered by muscles.

Disarticulation at the knee-joint ("Stephen Smith's operation").—The operation of removal of the distal part of the lower extremity, by disarticulation at the knee-joint, has been less and less practised by surgeons during recent years. It has been found by clinical experience that the resulting stump tends to have an enlarged or bulbous extremity, and not the conical one which it ought to be the aim of the operating surgeon to produce, if he wishes to enable the instrument maker to fit a comfortable artificial limb. The bulbous or enlarged distal end is dependent upon the width of the femoral condyles and the wasting of the muscles immediately above the level of the joint. At the time that the operation was devised it possessed greater advantages than it does at the present day. Then, in the pre-antiseptic period, there was less possibility of the occurrence of fatal results when the operation was performed through the knee-joint than through the lower portion of the femur, owing to the fact that the medulla of the bone was not exposed. In my opinion it is better, in those cases in which removal of the lower extremity either at, or immediately above, the level of the knee-joint is requisite, to perform the higher operation, since a far more satisfactory functional result follows.

Position.—The patient is placed in the dorsal position, with the legs projecting beyond the end of the table. The sound leg is fixed to the leg of the operation table with a bandage, so as to be kept out of the way. The operator stands on the outer side of the right leg, and on the inner side of the left. One assistant grasps the foot, so as to manipulate the limb as required. A second assistant stands opposite the operator.

Operation.—A point is selected on the anterior border of the tibia one inch distal to the tuberosity. With a short amputating knife an incision is made commencing at this point, extending vertically distally on the anterior aspect of the limb for a distance of two inches, then in a slightly curved direction with the convexity downwards round the lateral aspect of the limb to the middle line behind, and then upwards to the popliteal space as high as a point opposite the middle of the knee-joint. A similar incision is made on the other side, care being taken to make the medial flap a little longer than the external one.

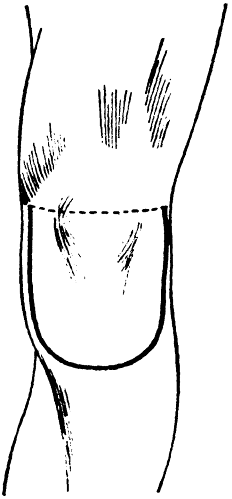

FIG. 525.—Amputation immediately above the knee-joint by a long anterior flap. Skin incision.

The incisions divide the skin and fasciæ, and then two flaps are dissected upwards consisting of these tissues. The ligamentum patellæ is divided, and the tissues which lie in front of the head of the tibia separated until the inferior margins of the menisci (semi-lunar cartilages) can be seen. The lateral ligaments and the anterior part of the capsule of the knee-joint are divided, and then, by a series of transverse cuts, the knife is passed through the knee-joint between the menisci and the head of the tibia. The cruciate ligaments are divided close to their attachment to the tibia. The posterior part of the joint being reached, the posterior ligament is exposed, and may be cut through, and then with one sweep of the knife all the soft tissues in the popliteal space are divided in a transverse direction backwards.

The popliteal artery and vein are picked up and ligatured, together with any smaller vessels which may have been cut through, and then the large nerves are dissected out for one inch and cut across.

The flaps are adjusted over the extremity of the stump, and fixed in apposition by the insertion of sutures, a drainage tube being inserted at one angle if there is much oozing.

When the wound has healed, the line of the scar is situated on the posterior part of the limb between the condyles of the femur, the extremity of the stump being well covered by soft tissues. The advantage of leaving the menisci is that the soft parts are kept in their places, and the danger of too great retraction of the flaps is avoided.

Amputations through the knee-joint have been also performed by making a long anterior and a short posterior flap, the main features of such operations being similar to those described in connection with amputations through the leg.

Amputations through the distal fourth of the thigh.—As has already been stated, it is advisable in all cases to recommend an operation through the distal portion of the thigh in preference to one through the knee-joint. The one which is the best for practical purposes—and enables a comfortable, useful, and painless artificial limb to be fitted to the stump—is a combination of those which were devised and recommended by Stokes and Gritti.

Antero-posterior (long anterior and short posterior) cutaneo-fascial flaps give the best results.

Four forms of operation in this region are described ; but, in my opinion, the one which will be found most valuable and assure the most useful stump is that in which the femur is divided transversely immediately above the condyles, the articular aspect of the patella is removed, and the two sawn surfaces of bone joined together. Of course, in those cases in which the patella is extensively diseased it will not be possible to perform this operation, and one at a slightly higher level must be adopted.

Position.—The patient is placed in the dorsal position, with the lower extremities, as far as the middle of the thigh, projecting beyond the end of the table. The sound limb is fastened to the leg of the table, so as to be out of the way during the operation. The surgeon stands on the right side of the thigh which is to be operated upon ; one assistant takes charge of the limb, and a second stands opposite the operator. An Esmarch's elastic tourniquet is applied round the upper part of the thigh on the affected side.

Operation.—*By a long anterior flap, with section of the femur immediately above the articular surface, and removal of the patella.*—This operation is often known as "Carden's amputation." Two points are selected, one on the lateral and the other on the medial side of the thigh, at the level of the condyles of the femur. An incision is made which commences (in the case of the right limb) at the selected point on the medial side and passes distally for about 4 inches, then across the front of the leg to the lateral side, and then proximally in a vertical direction to the selected point on the lateral aspect of the limb. The width of the flap so marked out should be half the circumference of the limb at the plane of section, and the distal extremity should be broadly convex.

The skin and fasciæ are divided for the entire length of the incision, and the flap dissected upwards until the proximal border of the patella is reached. The muscles attached to the superior margins and the lateral borders of the patella are cut through, and the knee-joint opened. The muscles are allowed to retract, and the flap dissected upwards to just above the level of the plane of section of the bone.

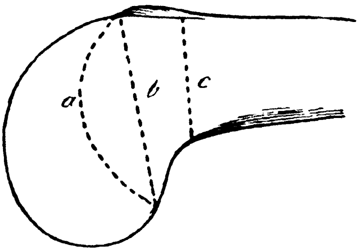

FIG. 526.—Lower end of femur, showing positions of section of bone.

a. In "Carden's amputation."
b. In "Gritti's amputation."
c. In "Stokes's amputation."

A long amputation knife is now passed behind the bone from the lateral to the medial extremity of the first incision. The cutting edge is turned backwards, and all the soft tissues divided by cutting directly towards the surface.

The soft parts are retracted by the assistant, the femur is cleared for a short distance above the articular surface, and the bone sawn through (Fig. 526, *a*). The limb can now be removed.

The thigh is flexed, so as to expose the cut surfaces of the flaps, and the popliteal artery and vein secured. The tourniquet is removed, and all other bleeding vessels (branches of the anastomosis around the knee-joint) are likewise ligatured. The large nerve trunks are directed upwards for 1 inch, and the exposed portions removed.

The broad anterior flap is brought over the extremity of the bone, and fixed in position by the insertion of sutures.

In many cases it will be advantageous to make a short posterior flap, in addition to the long anterior one, in order to provide an efficient covering for the stump.

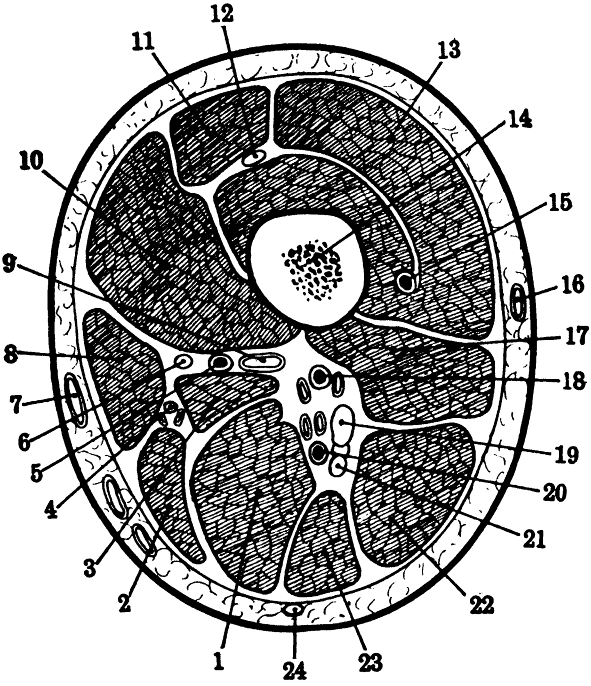

FIG. 527.—Transverse section of thigh through upper portion of popliteal space.

1. Semimembranosus.
2. Gracilis.
3. Adductor magnus.
4. Arteria suprema genu (anastomotica magna) and veins.
5. Femoral artery.
6. Saphenous nerve.
7. Large saphenous vein.
8. Sartorius.
9. Femoral vein.
10. Vastus medialis (vastus internus).
11. Rectus femoris.
12. Branch of femoral (anterior crural) nerve
13. Vastus lateralis.
14. Femur.
15. Lateral circumflex artery of the thigh.
16. Superficial vein.
17. Biceps femoris (femoral part).
18. Terminal branch of profunda femoris artery and veins.
19. Sciatic nerve.
20. Arteria comitans nervi ischiadici.
21. Sciatic nerve (internal popliteal part).
22. Biceps femoris (ischial part).
23. Semitendinosus.
24. Posterior cutaneous nerve of thigh.

(*b*) *By a long anterior flap, with section of the femur through the condyles, and removal of the articular aspect of the patella* ("*Gritti's operation*").—This form of operation resembles the preceding except that the knee-joint is opened below the patella, the ligamentum patellæ and the inferior part of the capsular ligament being cut through, and the patella dissected up in the anterior flap. The articular surface of the patella is removed with a fine saw (Fig. 526, *b*). When the flap is brought into position the cut surface of the patella should lie in apposition with the sawn extremity of the femur, the two bones becoming firmly united as healing takes place.

Much difficulty is often experienced in keeping the sawn surfaces in apposition, owing to the action of the muscles and the length of the femur. In order to obviate this, the following operation has been proposed, and in many instances gives rise to a better result than the preceding:—

(*c*) *By a long anterior flap, with section of the femur above the condyles, and removal of the articular aspect of the patella* (*"Stokes's operation"*). — This operation resembles the preceding in all essential respects, with the exception that the femur is sawn through at a higher level, —through the shaft immediately above the condyles (Fig. 526, *c*), —and the skin flaps are commenced at a slightly higher level. The sawn surface of the patella can be brought into and kept in apposition with the sawn surface of the femur much more readily than in the preceding operation. In order to effect this, it is usually advisable to fix them together by one or two sutures of silver wire, inserted at the posterior margin of the sawn surfaces.

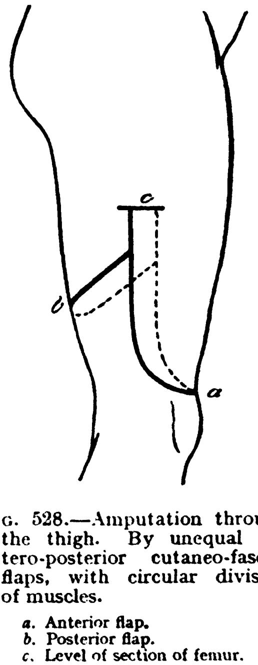

FIG. 528.—Amputation through the thigh. By unequal antero-posterior cutaneo-fascial flaps, with circular division of muscles.

a. Anterior flap.
b. Posterior flap.
c. Level of section of femur.

(*d*) Ssabanajeff has further modified this operation. He saws the lower end of the femur in a manner similar to Gritti, but leaves the patella intact. A segment of the tibia is fashioned by first sawing the bone in a vertical direction to a point a short distance below the tuberosity of the tibia and the attachment of the ligamentum patellæ, and then transversely until the second saw cut meets the first. By this method a portion of the tibia and the insertion of the quadriceps extensor muscles are separated. The sawn surface of the segment of the tibia and that of the distal end of the femur are brought into exact apposition, and fixed by the introduction of sutures. The advantages which are claimed for this method are the retention of the insertion of the quadriceps extensor muscle, the readiness with which the bony surfaces of the tibia and femur unite, and the more satisfactory stump which results. This procedure may be available in cases of injury and in early cases of tuberculous disease, but in advanced cases the state of the bones will not allow of its performance.

In the four preceding forms of amputation the resulting scar will lie on the posterior surface of the limb, and the covering for the end of the stump will be formed from the skin over the patella and the extensor aspect of the knee, which is well fitted to withstand pressure.

Amputations through the middle of the thigh.—Amputations through the middle portion of the thigh may be performed by the following methods :—

(*a*) By antero-posterior cutaneo-fascial flaps, with circular division of the muscles.

(*b*) By lateral cutaneo-fascial flaps, with circular division of the muscles.

(*c*) By the circular method.

(*d*) By the elliptical method.

(*e*) By a long anterior muscular flap.

Of these forms of operation those by antero-posterior or lateral cutaneo-fascial flaps, with circular division of muscles, are the best in the majority of instances. In all cases sufficient allowance must be made for retraction of muscles, the periosteum dissected upwards for one inch and afterwards sewn over the divided end of the bone in those cases which are aseptic at the time of operation, the large nerve trunks dissected out for a sufficient distance, and in sewing up the wound buried muscular sutures should be inserted.

Position.—The positions of the patient, surgeon, and assistants are similar to those in amputation through the lower fourth of the femur, with the exception that the affected limb should project farther beyond the end of the table.

The elastic tourniquet is placed on the thigh well above the level of the plane of section of the bone.

Operation.—(*a*) *By antero-posterior cutaneo-fascial flaps, with circular division of the muscles.*—A U-shaped incision is made, commencing on the side away from the operator, at the level at which it is proposed to divide the bone, and extending first vertically distally, then transversely across the front of the limb, and finally vertically proximally to a point opposite that at which it commenced (Fig. 529).

This incision marks out a flap with a broadly rounded extremity, in width equal to half the circumference, and in length to the diameter of the limb, at the level of the plane of section of the bone. The incision divides the skin, superficial and deep fasciæ, and these structures are dissected up to form the flap. A similar flap, half the length of the anterior one, is then marked out, and dissected up on the posterior aspect of the limb. Both flaps are retracted by an assistant, and with a circular sweep of the knife the muscles are divided down to the bone. The periosteum is cut through, and retracted for a short distance, and the femur sawn across.

The superficial and deep femoral vessels having been secured, the tourniquet is relaxed, and any bleeding points picked up and ligatured. The periosteum is sewn over the end of the femur, the portions of the large nerve trunks — sciatic and femoral — resected, and the cut ends of the muscles sutured.

The margins of the cutaneo-fascial flaps are then approximated, and united by sutures in the usual manner.

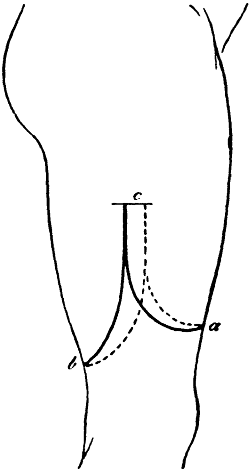

FIG. 529.—By equal antero-posterior cutaneo - fascial flaps, with circular division of muscles.

a. Anterior flap.
b. Posterior flap.
c. Level of section of femur.

The relative lengths of the flaps may vary according to the condition of the soft tissues. The flaps should be long enough to meet without tension, and to provide a scar which should not lie immediately over the end of the bone.

(*b*) *By lateral cutaneo-fascial flaps, with circular division of the muscles.*—This operation is similar in many respects to the preceding, but the skin incisions commence and terminate on the anterior and posterior aspects of the limb respectively, two equal lateral flaps being formed (Fig. 530).

(*c*) *By the circular method.*—A circular incision is made through the skin, superficial and deep fasciæ, 3 to 4 inches below the level at which it is proposed to saw the bone.

The divided tissues are dissected back in the form of a "cuff," and then with a circular sweep of the knife the superficial layers of muscles are cut through; these are allowed to retract, and then the deeper muscles are divided in a similar manner down to the bone. The latter is freed from its periosteum for a short distance, and then sawn through in the usual manner. All hæmorrhage having been arrested, the margins of the wound are brought together and fixed by the insertion of sutures.

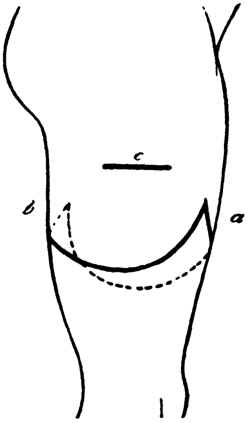

FIG. 530.—By lateral cutaneo-fascial flaps, with circular division of muscles.

a. External flap.
b. Internal flap.
c. Level of section.

(*d*) *By the elliptical method.*—Amputation by the elliptical method through the middle of the thigh is similar to amputation by the same method in other parts.

The distal extremity of the ellipse may be either anterior or posterior, preferably the former.

(*e*) *By a long anterior muscular flap.*—When this operation is performed, a long U-shaped flap is dissected up from the anterior aspect of the limb. At first it consists of skin and fasciæ, and then it includes the muscles.

It is, however, very rarely necessary to employ this form of amputation.

Amputation through the hip-joint.—Several varieties of operation are practised for the removal of the lower extremity at the hip-joint. These are the external "racket" method (of Furneaux Jordan), anterior racket method, antero-posterior flaps, lateral flaps, and the formation of flaps by transfixion.

The best methods for amputation in cases of extensive disease of the hip-joint are those by the external and anterior racket methods. They involve less loss of blood than any of the other methods, and provide a wound the cut surfaces of which can be fairly readily kept in apposition.

Position.—The patient is placed in the dorsal position, with the lower extremities and the buttock of the affected side projecting beyond the edge of the table. The sound limb is drawn aside and fixed to the leg of the table by a bandage. The surgeon stands on the right side of the affected limb. One assistant grasps the lower portion of the diseased limb, and rotates it as required; the second assistant stands to the right of the operator; a third assistant attends to the control of the blood vessels.

The circulation is best arrested by passing a strong elastic tourniquet around the junction of the thigh with the pelvis. This tourniquet is passed after the anæsthetic has been administered. The posterior part crosses the ischio-rectal fossa on the medial side of the ischial tuberosity. One end is brought round in front over the inguinal region, and the other round the gluteal region. The two ends meet over the highest part of the iliac crest.

A calico bandage is placed over the middle of the inguinal ligament, and underneath the rubber tube. When the ends of the tourniquet have been tightened, the calico bandage compresses the lower part of the external iliac artery, and the rubber tube the superior and inferior gluteal vessels. A third assistant attends to this tourniquet throughout the operation, and takes care to keep the calico bandage in front of the external iliac artery.

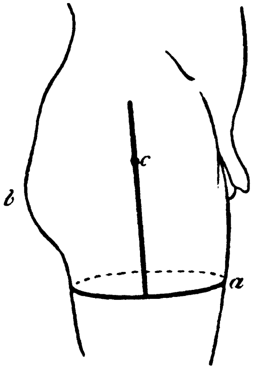

FIG. 531.—Amputation at the hip-joint ("external racket" or Furneaux Jordan's operation). Position of skin incision.

a. Circular portion of incision.
b. Vertical portion of incision.
c. Position of top of large trochanter of the femur.

Before the tourniquet is applied, the limb is elevated and the blood allowed to run out of it, in order to minimise the shock which usually follows loss of blood.

Operation.—A circular incision is made through the skin and fasciæ in the middle of the thigh, and the incised tissues dissected upwards for a distance of 2 inches. With one or two circular sweeps of the long amputation knife all the soft tissues, including the blood vessels, are divided down to the bone. The cut ends of the femoral vessels are sought for in the antero-medial part of the wound, and ligatured.

The patient is now turned a little on to the sound side, so as to expose more fully the gluteal aspect of the limb.

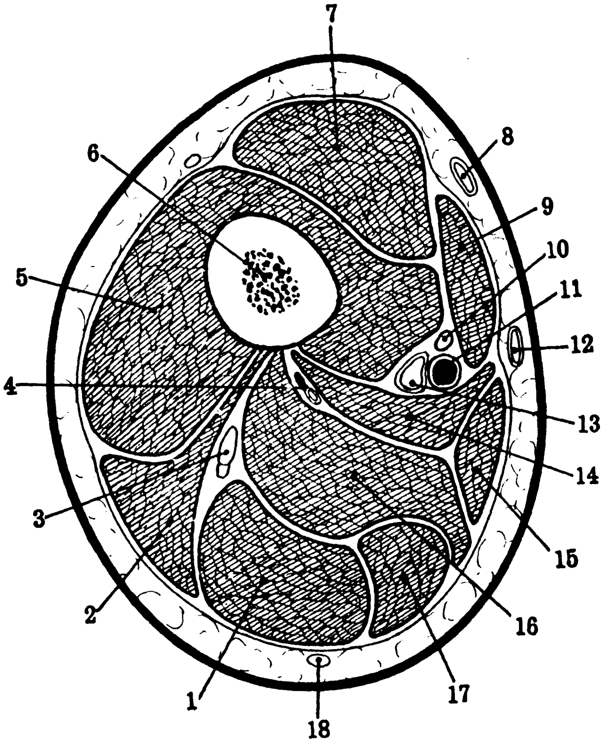

FIG. 532.—Transverse section through the thigh at upper part of middle third.

1. Semimembranosus.	10. Large saphenous nerve.
2. Biceps femoris.	11. Femoral artery.
3. Sciatic nerve.	12. Tributary of saphenous vein.
4. Profunda femoris vessels.	13. Femoral vein.
5. Quadriceps extensor.	14. Adductor longus.
6. Femur.	15. Gracilis.
7. Rectus femoris.	16. Adductor magnus.
8. Saphenous vein.	17. Semitendinosus.
9. Sartorius.	18. Posterior cutaneous nerve of the thigh.

A vertical incision is made along the lateral aspect of the thigh, commencing at a point half-way between the proximal border of the large trochanter and the iliac crest, and terminating in the circular incision distally. This cut is made with a short amputation knife, and all the tissues down to the femur are divided.

Next, the flaps are dissected up on each side, all the soft tissues being included, and the femur cleared from its connections with the muscles. Most difficulty will be experienced in detaching the muscles from the linea aspera. The femur is rotated by the assistant who has charge of the limb as this dissection proceeds.

The capsular ligament of the hip-joint is incised above and in front (if it is not already destroyed by disease), and the femur is rotated powerfully laterally, so as to make the head protrude from the acetabulum; the ligamentum teres and the posterior part of the capsular ligament are divided; and then any other soft tissues which are still attached to the femur are cut through with a few strokes of the knife.

The limb is now separated from its connections, and can be removed. Any bleeding points which may be apparent are picked up with pressure forceps and ligatured. The region of the acetabulum is then examined, and if any diseased bone is discovered it is scraped away with a sharp spoon. The large nerve trunks are dissected upwards for 1½ inches, and cut across and removed. The elastic tourniquet is gently relaxed, and any bleeding vessels which become visible are seized with forceps and ligatured.

All hæmorrhage having been arrested, and the tourniquet removed, the cut surfaces of the flaps are brought into apposition and fixed by the insertion of sutures. The angles of the wound are left open and a drainage tube passed into the depths of the wound, and then the stump is carefully and firmly bandaged.

The main branches of the superior gluteal artery are not interfered with, and only one of the lowest branches of the inferior gluteal is cut across.

If it is wished to minimise the loss of blood, the femoral vessels should be isolated during the first stage of the operation, ligatured in two places, and cut through.

Amputation at the hip-joint by the anterior racket method.—This operation is recommended when the position of the growth for which the operation is being performed does not allow the "external racket" method to be carried out with the maximum of safety. In addition, it permits either disarticulation at the hip-joint or a high division of the femur. The resulting shock does not appear to be more than that which follows the operation just described.

Position.—The positions of patient, operator, and assistants are similar to those already mentioned in the description of the "external racket" or Furneaux Jordan operation.

Operation. — An incision is made in the long axis of the thigh from 5 to 7 inches in length, according to the obesity and muscular development of the patient, which commences a little above the central point of the inguinal ligament (O.T., Poupart's) and extends directly downwards. The skin and fascial structures are first cut through and the common femoral vessels exposed in the upper portion of the incision. These are isolated, separated from one another, each ligatured in two places, and divided between, the artery being first dealt with so as to avoid as much as possible unnecessary loss of blood. The incision is next prolonged around the inner posterior and external aspects of the thigh in such a manner that the margin of the flap on the inner side is 4 inches below the inguino-perineal fold, and on the outer side a similar distance distal to the base of the great trochanter of the femur.

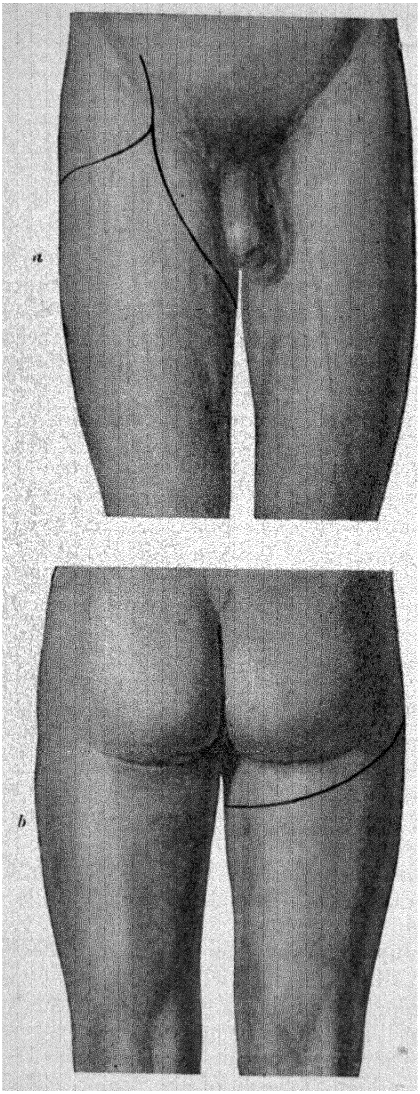

FIG. 533.—Amputation at hip-joint by anterior racket method. Skin incision.
a. Anterior view. *b.* Posterior view.
(BURGHARD.)

The skin and fascial tissues are dissected upwards for about 2 inches or more if the position and extent of the growth demands it, and then the muscles are cut through, first on the inner side and near their attachments to the pelvis, after the proximal ends of the divided femoral vessels have been protected and pushed upwards out of the way by an assistant. This procedure will expose the capsular ligament of the hip-joint on the anterior and internal aspects. This capsular ligament is freely divided, and the cavity of the joint opened. An assistant then forces the head of the femur out of the acetabulum, whilst the surgeon by a series of cuts posterior to the neck of the femur first divides the ligamentum teres, the posterior portion of the capsular ligament, and the muscles on the posterior and external aspects of the limb. The amputated limb is removed by an assistant, whilst the surgeon rapidly picks up the divided branches of the gluteal and sciatic arteries. All bleeding vessels are ligatured, and the ends of the sciatic and anterior crural nerves dissected upwards for 1½ to 2 inches and then cut across. If it is very desirable to minimise the resulting shock as much as possible, these nerve trunks may first be injected with novocain a short distance proximal to the level of the proposed division. The extremities of the divided muscles on the flexor and extensor aspects of the stump are joined together by sutures of catgut, and the skin margins with strong salmon-gut. The lower and external angle of the wound should be left unsutured, and through this a rubber drainage tube passed upwards as far as the region of the acetabular cavity. Dressings are then applied and fixed in position by firm even bandaging.

When the situation and connections of the growth for which the operation is being performed permit the femur to be sawn across through the base of the trochanters, the muscles are cut through by a few circular sweeps of the amputating knife 2 inches or thereabouts above the incision in the skin and fascial structures.

The other methods of amputation through the hip-joint are not so satisfactory in cases of extensive disease as the two above described, but are better adapted for primary amputation after injury, and in the operative treatment of malignant disease with involvement of the inguinal lymph glands.

They resemble in most respects similar amputations in the middle of the thigh.

CHAPTER XXX

OPERATIONS UPON THE MAMMARY GLAND

OPERATION FOR MAMMARY ABSCESS.

REMOVAL OF LOCALISED NON-MALIGNANT TUMOURS AND CYSTS.

REMOVAL OF THE BREAST—
  (*a*) For non-malignant affections.
  (*b*) For malignant disease.

THE mammary gland is situated on the antero-lateral aspect of the chest wall, and lies between two layers of the superficial fascia. In front of it lie the skin and the anterior lamina of the superficial fascia, and behind it the deep lamina of the superficial fascia, the deep fascia, and the pectoral muscles covering the surfaces of the ribs and the intercostal spaces.

The gland is divided into a number of lobes, these lobes being separated from one another by processes of fascia. Fig. 534 is a representation of a dissection of the lateral and superficial part of the mammary gland.

OPERATION FOR MAMMARY ABSCESS

An operation is indicated in all cases of inflammation of the breast in which the formation of pus has taken place. Before undertaking an operation for the evacuation of the pus the locality and extent of the abscess should be ascertained as far as possible by careful palpation.

Operation.—The position of the abscess having been ascertained, an incision is made over the most prominent portion, commencing a short distance from the nipple, and radiating from this point toward the periphery of the gland. The length of the incision varies according to the extent of the abscess cavity. When the interior of the abscess is reached, the margins of the incision are separated with dressing forceps or the fingers, and the pus allowed to escape.

The pus having been evacuated in the above manner, the forefinger is passed into the abscess cavity and an examination made of its interior, so as to discover any adjacent collections of pus, which have not been opened by the first incision.

The majority of acute abscesses of the breast are multilocular, and involve several lobes of the gland, and the strong connective tissue septa, which separate the lobes from one another, are not disintegrated so readily by the inflammatory process as the glandular tissue. If further collections of pus are discovered, the fibrous septa separating them from the cavity of the abscess are completely broken down with the finger, in order to allow the escape of the contents, and to provide free drainage. If it is difficult to establish thorough drainage from a single incision, owing to the size of the abscess, a second and even a third incision may be made. These should radiate from the nipple, and be placed at the lower limits of the abscess cavity.

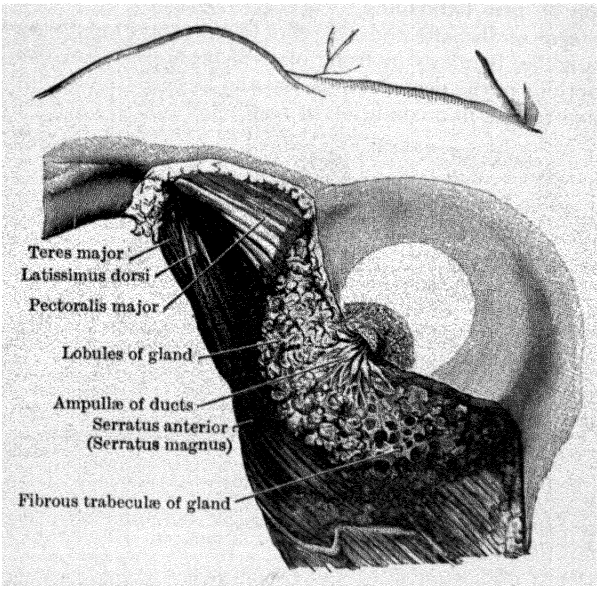

FIG. 534.—Representation of the structure and relations of the mammary gland.—CUNNINGHAM.

When free communications have been established between the abscess cavity and the exterior, and all pus has been evacuated, the interior of the abscess is thoroughly swabbed out and irrigated with an antiseptic solution.

Next, drainage tubes are inserted, or the interior may be packed with gauze, in the latter case a piece of sheet rubber is placed around the cutaneous opening, so as to minimise the pain when the packing is removed, and dressings applied and fixed in position by firm bandaging.

The arm of the affected side should be supported by a sling or triangular bandage in front of the chest, in order to avoid contractions of the pectoral muscles, and so help to maintain the inflamed tissues in a condition of rest.

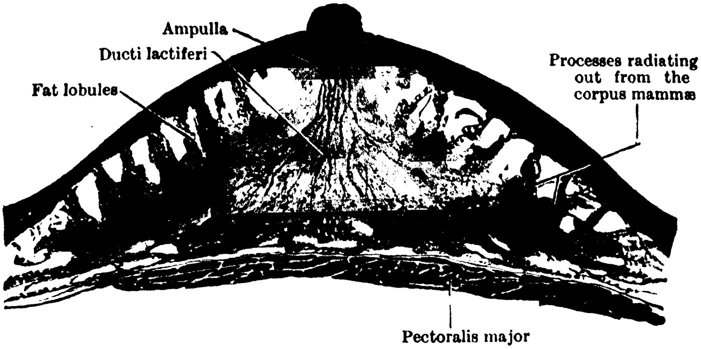

FIG. 535.—Section through pectoral region and mammary gland, showing relation of gland to adjacent structures.—CUNNINGHAM.

When the abscess is situated behind the mammary gland it will be found more convenient to lift up the organ towards the neck, and to make the incision in the sulcus between the gland and the chest wall (Fig. 536, *b*). No readily visible scar will result from this procedure.

REMOVAL OF LOCALISED NON-MALIGNANT TUMOURS AND CYSTS FROM THE MAMMARY GLAND

Fibro-adenomata and simple cysts are frequently met with affecting the mammary gland, and, very rarely, other forms of innocent tumour such as fibroma, myoma, myofibroma, lipoma, and enchondroma, and when present require removal.

Operation.—An incision is made over the most prominent part of the tumour, in a direction radiating from the nipple (Fig. 536, *a*). The skin, fasciæ, and fibrous tissue capsule of the tumour or cyst are divided and the tumour exposed. This is dissected from its surroundings and removed. Hæmorrhage is arrested, and the external wound closed. The margins of the deep portion of the space from which the swelling has been taken out should be fixed together by the insertion of sutures of catgut, and, if requisite, the margins of the cutaneous wound with sutures of very fine salmon-gut inserted with a very fine round needle. This method of closing the wound leaves the least possible scar. Dressings and bandages are applied, and the limb supported in front of the chest, as in the preceding operation.

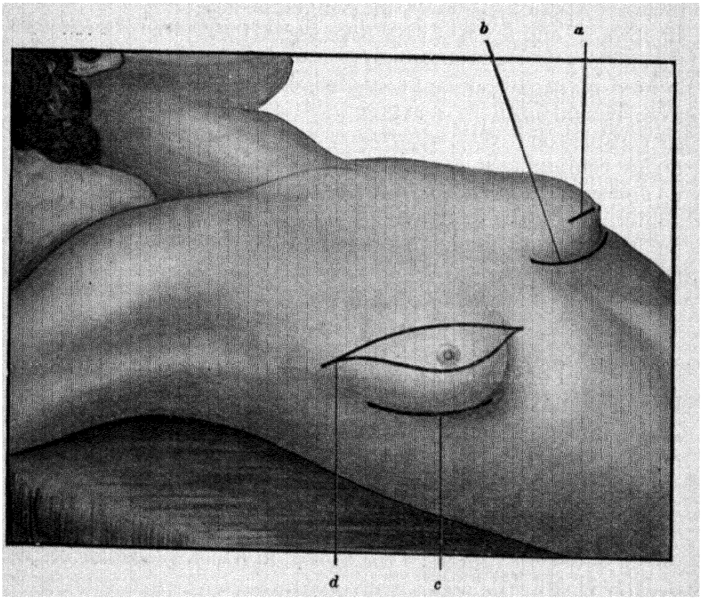

FIG. 536.—Position of incisions in removal of localised cysts or tumours of the breast.

a. Radiating incision from nipple
b. Incision in sulcus between breast and chest wall.
c. Incision on lateral side.
d. Incision for removal of breast for non-malignant affections.

When the tumour or cyst is situated in the lower part of the mammary gland, an incision may be made in the sulcus between the organ and the chest wall, the gland incised from its posterior aspect, so as to expose the deep surface of the tumour or cyst, and through this opening the abnormal structure is removed. No visible scar results from the procedure. A similar method can be adopted when a cyst or tumour occupies a portion of the upper half of the breast, and it is desired that an exposed scar should not result from the operation. In such cases a semilunar incision in the position depicted in Fig. 536, *c*, is made, the breast is separated from the pectoral fascia and turned upwards; or upwards and inwards according to the position of the cyst or tumour. The exact position of the cyst or tumour is next located by palpation, and a cut made through the breast tissue from behind until it is exposed. It is then turned out from its capsule, or if very adherent, a wedge-shaped portion of the breast containing it is excised. All bleeding points are picked up and tied, the cavity from which the tumour has been removed obliterated by the insertion of buried sutures of catgut, and the internal wound closed. A drainage tube should be kept in for forty-eight hours.

REMOVAL OF THE BREAST

Removal of the breast not accompanied by removal of the lymph glands of the axilla.—*Indications.*—(1) Chronic interstitial inflammation of the breast, which is not amenable to ordinary palliative measures.

(2) Tuberculous disease of the breast associated with or without numerous sinuses, and without enlargement of the axillary lymph glands.

(3) Serocystic disease of the breast, in which the whole or the greater part of the organ is involved.

(4) Actinomycosis of the breast.

Position.—The patient is placed in the dorsal position on the operation table, with the affected side close to the edge. The upper extremity of the diseased side is held at right angles to the trunk by an assistant. The surgeon stands on the affected side of the patient, and his assistant on the opposite side.

Removal of the breast (without clearing out the axilla).—*Operation.*—An oval-shaped incision is made, which includes the nipple and the areola, as shown in Fig. 536, *d*. The upper part of this incision is made first, and divides the skin and superficial fascia, and exposes the anterior aspect of the gland. The skin and fascia are dissected upwards until the superior margin of the mamma is exposed; this is pulled downwards, and the dissection continued on its posterior aspect. When the upper part of the breast has been freed, the organ is retracted upwards by an assistant, and the lower half of the incision made. The skin and fascia are dissected up until the inferior margin of the gland is laid bare, then by a few strokes of the knife the posterior aspect is separated from the fascia and the gland removed.

In cases of chronic inflammatory or of cystic disease of the mammary gland, the dissection should not extend beyond the superficial surface of the pectoral fascia.

When the gland has been removed all bleeding vessels are tied, the interior of the wound sponged out, and its margins united by the insertion of interrupted sutures. It is often advantageous to leave the lower angle of the wound open, and put in a drainage tube which is removed at the end of twenty-four hours. Dressings and bandages are applied, and the arm supported in front of the chest, as in the previous operation.

Removal of the breast, together with the lymph glands from the axilla and the peri-mammary tissues.—*Indications.* —1. *Carcinoma of the breast.*—It has been almost universally decided now, by surgeons who have had extensive experience in operations upon patients suffering from carcinoma of the mammary gland, that in almost all cases of this disease (with the possible exception of those cases in which the disease commences in the sternal margin of the gland), which are amenable to operation, and in which there are no marked contra-indications, a very extensive operation should be performed. It is necessary to remove not only the mammary gland itself, but also the overlying skin of the mammary region, including the nipple and areola, the surrounding connective tissue containing lymph vessels and fat, the underlying pectoral fascia and sternal portion of the pectoralis major muscle, the pectoralis minor muscle, the axillary groups of lymph glands which receive the lymph vessels from the mammary gland and mammary region, and the connective tissues and fat in the axilla. The operation should be so designed and carried out, that all the tissues above enumerated are taken away in one mass.

Concerning the question of dividing the pectoralis minor muscle, some advise that it should not be removed. In my opinion, however, it is better to remove a portion, since this facilitates removal of the axillary tissues, and so ensures complete removal of all possibly cancer-infected areas. Removal of a portion of the pectoralis minor does not seriously impair the usefulness of the limb beyond that which has been effected by other parts of the operation. Personally, I think that a portion of the muscle ought to be removed in all cases of carcinoma, since the lymph vessels from the upper portion of the breast join the lymph glands upon the costo-coracoid membrane, and in their course to these glands they pass through the fascia which forms a sheath to the muscle.

When the supra-clavicular lymph glands are enlarged in carcinoma of the breast, the primary disease, together with the lymph glands, may be removed; but it is not always possible to effect complete removal of the affected glands at the root of the neck. In this case, however, the secondary growths do not always increase in size very quickly, so that it often happens that life is prolonged for a considerable time after the removal of the primary disease.

The conditions which *contra-indicate* removal of the breast for carcinoma are—

(1) Extensive involvement of the skin, either by scattered nodules or general infiltration.

(2) Fixity of cancerous mass to bony wall of chest.

(3) The presence of visceral growths.

(4) Extensive involvement of the lymph glands above the clavicle.

(5) Marked œdema of the arm of the affected side.

(6) Some constitutional affections, such as diabetes.

2. *Sarcoma of the breast.*—If there are signs or symptoms which justify a diagnosis of the presence of secondary growths in any of the viscera or bones of a patient suffering from sarcomatous disease of the breast, it is not advisable to perform an operation for the removal of the primary disease. When, however, there are no contra-indications of this kind, removal of the breast should be invariably carried out. In early cases of the disease it is not always considered necessary to remove the axillary contents, as has been recommended in the case of carcinoma; but whenever there are signs that the disease has commenced to infiltrate the surrounding tissues the complete operation should be performed, and in my opinion it is always better to do so.

3. *Tuberculous disease of the breast, associated with a similar affection of the axillary lymph glands.*—Tuberculous disease of the breast is not very common; when, however, it occurs it usually causes, at a comparatively early stage, a similar affection of the lymph glands in the axilla. The breast and axillary lymph glands should be removed, but it is not generally necessary to remove the sternal portion of the pectoralis major

Removal of the breast together with the lymph glands from the axilla and the peri-mammary tissues (complete operation).—The lymph vessels from the lateral portion of the breast

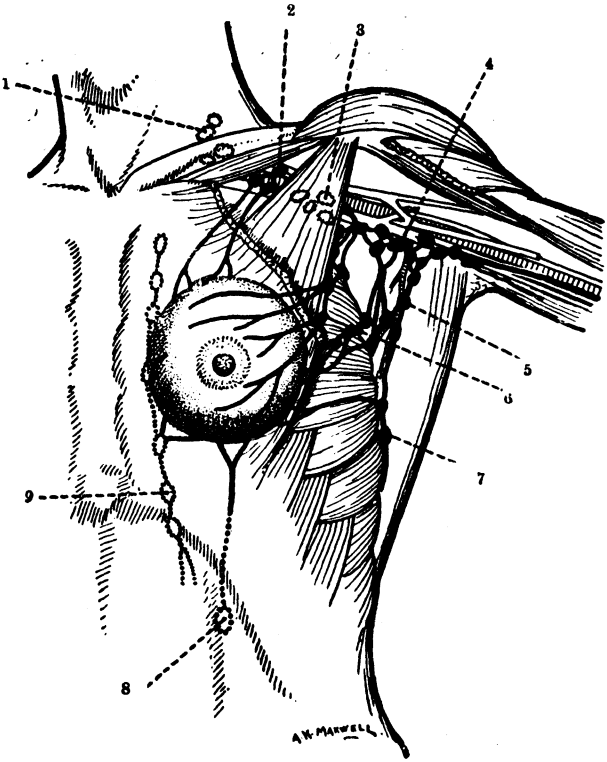

FIG. 537.—Course of the lymph vessels from the breast, and the groups of glands into which they open.

1. Supra-clavicular lymph glands.
2. Infra-clavicular „ „
3. Apical group of axillary lymph glands.
4. Central „ „ „ „
5. Posterior „ „ „ „
6. Pectoral (or anterior) group of axillary lymph glands.
7. Thoracic (or inferior) group of axillary lymph glands.
8. Lymph gland in sheath of rectus abdominis muscle.
9. Anterior mediastinal group of lymph glands.

pass laterally and join the lymph glands in the axilla. From the upper part they go to those on the costo-coracoid membrane, and from the medial margin to those in the superior and anterior mediastina. Fig. 537 is a diagrammatic representation of the course of the lymph vessels from the mammary gland to the different groups of lymph glands to which they go. The majority of the lymph vessels from the breast pass into the axilla, a few from its upper margin to the glands on the costo-coracoid membrane, and those from the medial portion to the glands within the chest.

Position.—The patient is placed in the dorsal position, with the affected side of the thorax projecting slightly over the margin of the operation table. The shoulders are slightly raised by placing a pillow or other support underneath them. The upper extremity of the affected side is abducted, and held at right angles to the trunk by an assistant, who is detailed for this purpose. This assistant manipulates the limb, if requisite, during the course of the operation. The surgeon stands on the affected side of the patient, between the abducted upper extremity and the trunk, and his chief assistant opposite to him.

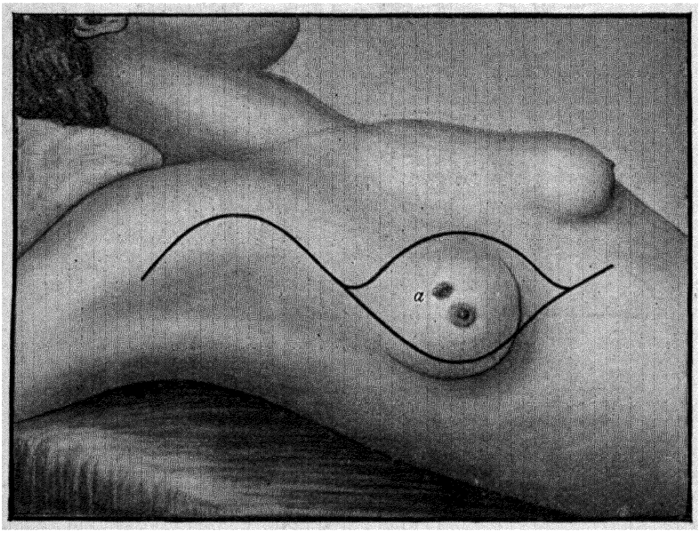

FIG. 538.—Removal of breast and contents of axilla. Skin incision.
a. Position of growth.

Operation.—*Skin incision.* — The exact lines of the skin incisions vary according to the site of the carcinoma in the mammary gland and the amount of involvement of the skin, if any. Usually they are elliptical or pyriform in shape, the broad part enclosing the mammary prominence, and the narrow being extended along, and some little distance above, the anterior fold of the axilla to a point where the upper extremity joins the trunk. Fig. 538 represents the most useful form of incision which can be adopted in removal of the breast and axillary contents, the upper portion representing the part extending to the axilla, and the lower the prolongation downwards and medially toward the upper part of abdomen. The essential points which every one must observe in making the skin incisions are to be certain that they are wide of any involved area, and that they do not extend in depth beyond the skin and subcutaneous fascial layer. The mammary gland lies between two layers of superficial fascia; hence, if great care be not taken in dissecting back the skin flaps, superficial and outlying portions of the mammary gland will be left behind, and become the starting-points of a local recurrence of the disease. When operating upon the right breast the skin incision commences at the anterior fold of the

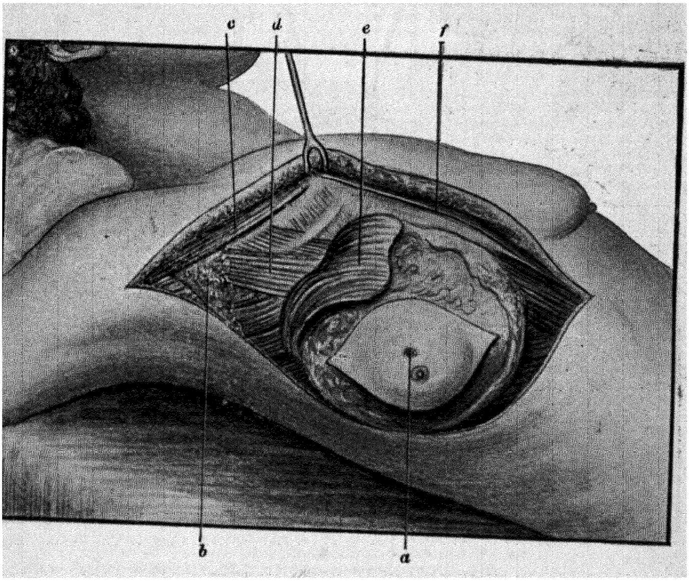

FIG. 539.—Removal of breast and contents of axilla.

a. Affected portion of skin.
b. Axillary fat, lymph glands, etc.
c. Clavicular part of pectoralis major.
d. Pectoralis minor.
e. Sternal part of pectoralis major.
f. Divided margin of deep pectoral fascia.

axilla, where the upper extremity joins the trunk, and then proceeds in an elliptical manner inwards and downwards over the anterior fold of the axilla, and the pectoral and mammary regions until a point is reached near the lateral margin of the sternum, and below and medial to the lower portion of the medial and inferior quadrant of the mammary gland. The second portion of the incision is also elliptical in shape, encircles the mammary eminence, and extends from the termination of the first incision, below, around, and lateral to the breast until it joins the first about the middle of the anterior fold of the axilla. The exact directions of these incisions vary a little according to the locality of the cancerous mass, but in all cases they encircle the entire mammary eminence, and some of the adjacent skin (Fig. 538). The skin along the entire margins of the wound is dis-

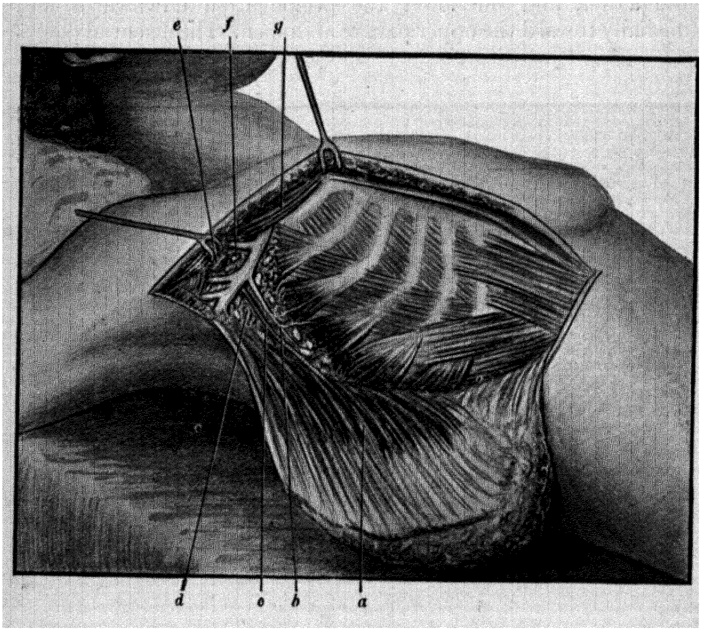

FIG. 540.—Removal of breast and contents of axilla. Appearance of wound when upper portion of dissection has been made.

a. Deep aspect of pectoral muscles.
b. Lateral thoracic vein.
c. Lateral thoracic artery.
d. Fascia and lymph glands around axillary vessels.
e. Divided pectoralis minor.
f. Lymph gland on lateral side of axillary vein.
g. Lymph structures at apex of axilla.

sected up from the underlying tissues, until the confines and boundaries of the mammary gland and any of its prolongations have been passed. The deeper fat and fasciæ are now cut through in the upper part, and the sternal portion of the pectoralis major and its sheath of deep fasciæ exposed (Fig. 539). The scalpel is next carried through the pectoralis major muscle, together with the fascia lying above and below it, and the muscle separated from its attachments and connections with the thoracic wall. At this stage the perforating branches of the internal mammary artery will be cut through, and require ligature. By this dissection the entire mass which is to be removed can be thrown laterally, and then the pectoralis major muscle is cut through close to its attachment to the humerus. The costo-coracoid membrane, the pectoralis minor, and the upper portion

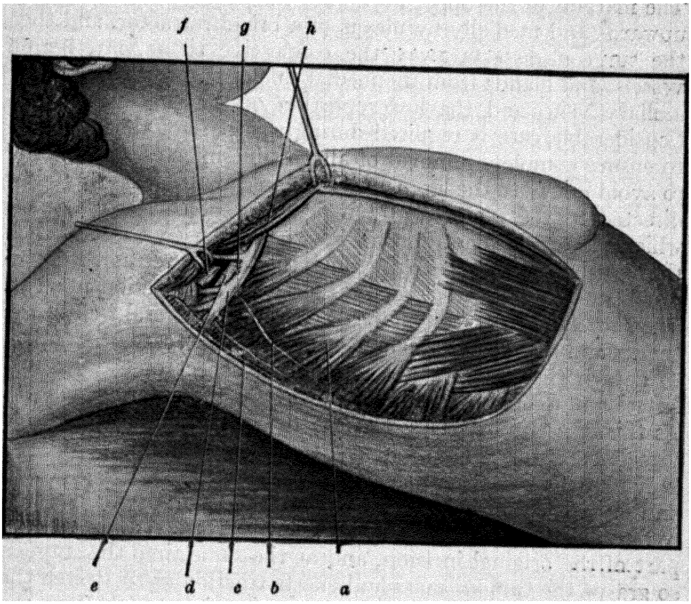

FIG. 541.—**Removal of breast and contents of axilla for carcinoma.** Appearance of wound after removal of affected structures.

a. Serratus anterior (serratus magnus).
b. Long thoracic nerve.
c. Margin of divided axillary fascia.
d. Axillary vein.
e. Axillary artery.
f. Divided lateral end of pectoralis minor.
g. Divided lateral thoracic vessels.
h. Clavicular portion of pectoralis major.

of the axilla are now fully exposed. The connective tissue and lymph vessels and glands which lie above the pectoralis minor, and in relation with the costo-coracoid membrane, should be separated by careful dissection, and removed, together with the pectoralis minor and its thin fascial envelope. By these proceedings the pectoralis minor and its fascial coverings are freed. The margins of the upper portion of the incision are now pulled upwards and medially by means of a broad retractor, and then the surgeon dissects away the connective tissue, fat, lymph vessels, and glands from the medial side of and surrounding the axillary vein, and the lower portion of the subclavian vein. Considerable care is required during this part of the operation to ensure complete removal of all possible infected tissues, and to avoid injury to the large vessels. Special attention should be directed to the removal of the processes of connective tissue which pass in front of and behind the axillary vessels. When the vessels have been cleaned thus, the mass is retracted downwards and laterally by the assistant exerting traction upon it. The surgeon dissects the mass away from the lateral wall of the thorax and the medial wall of the axillary space, care being taken to detach the fascia from the external aspect of the serratus anterior muscle and the upper portion of the external oblique. As this dissection is being performed, the branches of the large vessels are cut, and ligatured as they become exposed.

When this has been done, and the junction of the posterior and lateral walls of the axilla reached, the assistant is directed to retract laterally the skin which forms the lateral and posterior part of the original incision, and at the same time the surgeon so grasps the tumour mass and exerts traction as to stretch the vessels and nerves which pass to the muscles, which form the posterior axillary wall. The axillary contents, by dissection from above and internally downwards and laterally, are carefully separated from the posterior axillary wall, the vessels being seized with pressure forceps as exposed before division, and the subscapular and lateral thoracic nerves, if possible, being saved. Great care should be taken to remove the connective tissue and enclosed lymph glands which lie in the angle between the serratus anterior and the inferior part of the subscapularis. When the posterior and lower portion of the axilla has been reached, one or two cuts are made in a lateral direction, and then the entire mass can be removed. Fig. 542 shows the appearance of the mass when removed.

All bleeding points are now secured with ligatures, and the pectoralis minor, if simply divided, united by sutures. If there is any difficulty in thoroughly exposing the tissues in the region of the costo-coracoid membrane, a cut may be made at right angles to the upper portion of the incision, so as to give a better exposure; and when the supraclavicular lymph glands are enlarged, this cut may be extended into the posterior triangle of the neck, and through it any enlarged glands taken away. It is not generally necessary to divide the clavicle in order to obtain complete exposure of the supraclavicular lymph glands.

Closure of the external wound.—This is not always possible but very often much aid can be obtained in this respect by making incisions backwards and forwards, and dissecting up the skin as in a plastic operation. Often the wound can be completely closed in by this proceeding. On three occasions, in the case of women with very pendulous breasts, in whom it was necessary to remove a considerable area of skin, I was enabled absolutely to close the wound by dissecting up the breast of the opposite side, freeing it at its lower and external margins, and transplanting it so as to cover the entire wound.

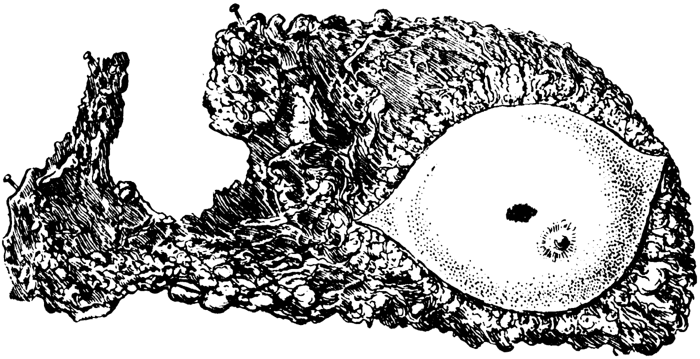

FIG. 542.—Removal of breast and contents of axilla. Appearance of mass, consisting of mammary gland, skin, axillary lymph vessels and glands and fat, and portions of pectoral muscles.

When it is not possible or advisable to close the external wound, it is recommended that at a later date the unclosed area be grafted with skin grafts by the epidormal strip or Thiersch's method. As a certain amount of subsequent oozing always follows this operation, it is wise to drain the axillary region for twenty-four hours by means of a rubber tube brought out through a small incision in the outer and lower skin flap.

After-treatment.—When the dressings have been applied and fixed by firm bandaging, the arm of the affected side is allowed to rest on the chest wall supported by a triangular bandage. After four or five days the patient is encouraged to move it slightly. This precaution avoids unnecessary delay in recovery of the use of the arm, as almost invariably follows when the limb is kept fixed to the side for a long period.

The results which have followed this form of operation are much better than those obtained by the older methods of removing merely the breast and any lymph glands which happened to be enlarged. The latest statistics appear to show conclusively that in favourable cases 40 to 50 per cent. or more of recoveries may be expected.

CHAPTER XXXI

PLASTIC OPERATIONS

HARE-LIP.
  (*a*) Single.
  (*b*) Double.

CARCINOMA OF THE LIP.

CLEFT PALATE.
  (*a*) Of both hard and soft palate (complete).
  (*b*) Of soft palate (incomplete).

OPERATION FOR EXTROVERSION OF THE URINARY BLADDER.

OPERATION FOR EPISPADIAS.

OPERATION FOR HYPOSPADIAS.

SKIN GRAFTING.
  (*a*) By ordinary method (or Reverdin's).
  (*b*) By large epidermal strips (" Thiersch's method ").

PLASTIC SURGERY

By the term " plastic surgery " is understood those operative measures which have for their object the repair of malformations or deficiencies which are due to congenital or acquired causes.

The congenital malformations which are most common, and which can be repaired by surgical aid, are the different varieties of hare-lip and cleft palate, and malformations of the genital organs, such as epispadias, hypospadias, and extroversion of the bladder. Webbed fingers occasionally occur, and can be remedied by surgical treatment.

Acquired malformations may be dependent either upon disease or upon injury. The former class includes loss of part or the whole of the nose by ulceration, and the different forms of contraction, which cause deformities, and are due to the scars of healed ulcers. The deformities or deficiencies which are due to injury may be the result of severe contractions after burns, to the accidental removal of some part, such as the nose, by a sharp instrument, or to the removal of some organ by the surgeon in the treatment of a disease, especially a malignant growth, such as a rodent ulcer of the face, or a carcinoma of the lip.

Skin grafting is so intimately associated with many forms of plastic operations and the repair of defects, that it has been considered advisable to include it in this chapter.

HARE-LIP

A hare-lip is a congenital affection which is due to the non-closure or incomplete closure of the original cleft between the central (endognathion) and lateral (exognathion) portions of the upper lip. When it occurs on one side only it is called a *single* hare-lip, and when on both sides a *double* hare-lip. A *median* hare-lip may occur, but it is exceedingly uncommon. When present it is usually associated with non-development of the intermaxillary bone, but cases have been seen in which this bone has been fully formed. In this latter case possibly a lateral cleft has been drawn towards the middle line.

Period of life at which the operation is best performed.—The period of life at which the repair of a hare-lip has been carried out has varied in the practice of different surgeons. Operation at some date between the termination of the fourth week and that of the fourth month appears to have been followed by the best results, the most favourable time being between the sixth and eighth week.

If the operation is performed after the end of the sixth month the complications of dentition are liable to interfere with the success of the operation, and before the fourth week the infant is not always strong enough to stand such an operation.

(*a*) **Single hare-lip.** — *Special instruments.* — Long-handled fine scalpel or tenotome, fine-toothed long-handled forceps, suture material (fine salmon-gut or horsehair).

Position.—The patient is placed in the dorsal posture on the operation table, with a sterilised towel wrapped around the chest and arms. The operator stands at the head of the patient, the assistant on the affected side, and the anæsthetist on the opposite side.

Chloroform is the anæsthetic which should be used, and care must be taken that no drops of it fall on the face of the infant, especially in the region of the wound.

Operation.—The operation for the cure of hare-lip may be divided into four stages, namely—(*a*) Incision of the mucous membrane at the reflection between the cheek and the alveolar process, and separation of the two parts of the lip from the external surfaces of the maxilla ; (*b*) paring of the margins of the cleft in the lip ; (*c*) fixation of the prepared margins and surfaces in apposition, by the insertion of sutures ; (*d*) application of a dressing which will maintain the parts in position.

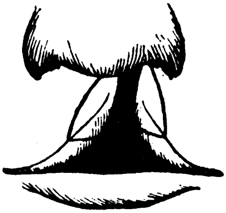

FIG. 543.—Single hare-lip. Positions of incisions along the margins of the cleft.

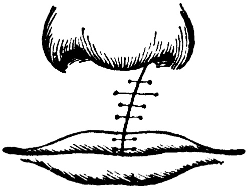

FIG. 544.—Single hare-lip. Appearance of the upper lip after the cleft has been closed.

(*a*) *Incision of mucous membrane.*—The margins of the cleft portion of the lip are held apart, and the mucous membrane on the internal surface cut through along its line of reflection from the gums. Next, the lip is dissected upwards for a short distance, so as to allow the easy approximation of the margins of the cleft without the production of tension. In severe cases it may be necessary to effect this separation almost to the infra-orbital foramen on the affected side. The attachment of the ala of the nose to the maxilla is also cut through during the separation of the tissues of the cheek. This avoids flattening, and malformation of the nostril of the cleft side.

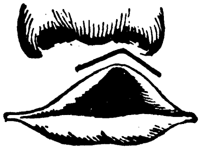

FIG. 545.—Single hare-lip. "Nélaton's operation." Position of the incision.

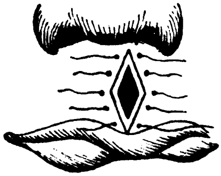

FIG. 546.—"Nélaton's operation." Appearance of parts after the incision has been made, the apex of the cleft drawn downwards, and the sutures inserted.

Whilst this separation of the tissues of the cheek is being effected, the edge of the scalpel should be kept turned towards the surface of the maxilla, and away from the cheek.

Any hæmorrhage which occurs can usually be controlled by sponge pressure.

(*b*) *Paring margins of cleft.*—The methods of paring the edges of the cleft in the lip vary according to the characters of each individual case. The main points to be borne in mind are that the margins of the incision should correspond, that the line of union of the cleft should be a little longer than is apparently requisite, so as to allow for contraction of the scar tissue along the line of union, and that the red line of the lip should be quite regular and even.

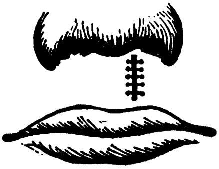

FIG. 547.—"Nélaton's operation." Appearance of the lip when the sutures have been tied and the operation completed.

It is only in slight and extremely favourable cases that a good result can be obtained by this procedure.

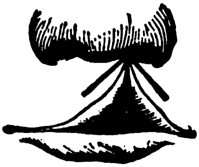

FIG. 548.—Single hare-lip. Operation of Malgaigne. Position of incisions at the margins of the cleft.

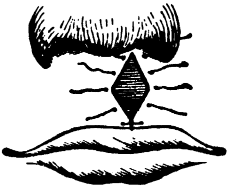

FIG. 549.—Single hare-lip. Operation of Malgaigne. Appearance of cleft when the margins have been pared and the sutures inserted.

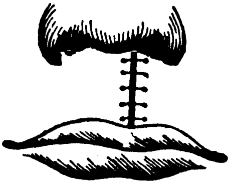

FIG. 550.—Single hare-lip. Operation of Malgaigne. Appearance of the lip when the operation is completed.

A thin-bladed scalpel is taken, its point entered at the apex of the cleft or at the nostril (when the malformation is complete), with the cutting edge towards the mouth, and then a cut is made in a straight or somewhat curved direction as far as the junction of the skin with the mucous membrane, then the blade is turned towards the cleft and a further cut made at an angle of 50° to 70°, according to the width of the cleft. The manner of making this incision is shown in Fig. 554. This is the operation which is recommended by Rose. Other methods of making the incisions in the margins of the cleft are shown in Figs. 545, 548, and 551.

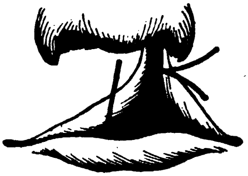
FIG. 551.—Operation of Giraldès. Position of incisions at the margins of the cleft.

The other side of the cleft is then treated in a similar manner, the hæmorrhage being controlled by the fingers of the assistant, or by putting on a suitable lip compressor. Usually it will be found more convenient to adopt digital pressure.

(*c*) *Insertion of sutures.*—The margins of the cleft, having been prepared as above, are brought together and fixed in this position by the insertion of a series of simple interrupted sutures.

Fine straight needles are taken, and threaded with fine salmon-gut. The first needle is passed a little above the junction of the skin with the red portion of the lip, its point being entered one-fourth of an inch from the margin, and made to emerge at the junction of the cut surface with the mucous membrane on the internal aspect, and then to pass through the lip on the other side in the reverse direction. The second needle is passed in a similar manner at the upper extremity of the cleft, and a third half-way between the two first. Other sutures of fine horsehair are now passed between the three main sutures, along the other parts of the margins of the cleft, both on the internal and external surfaces. As these are being

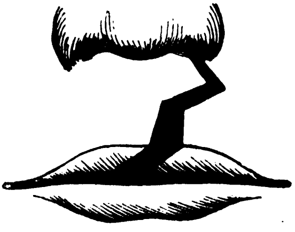
FIG. 552.—Operation of Giraldès. Appearance of cleft after the margins have been pared.

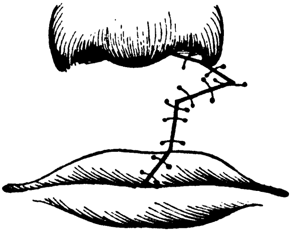
FIG. 553.—Operation of Giraldès. Appearance of lip when the operation has been completed.

introduced, the salmon-gut sutures should be tightened, so as to bring the margins of the cleft in exact apposition.

The three salmon-gut sutures are now tied with the first part of the true " surgical knot " (Fig. 73), and the horsehair sutures in a reef knot in the usual manner. The ends of all the sutures are cut short. The margins of the divided mucous membrane on the inner aspect of the lip should also be fixed in apposition by the insertion of a few interrupted sutures of fine catgut.

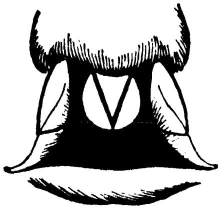

FIG. 554.—Double hare-lip. Position of incisions along the margins of the cleft and on the prominence of the permaxilla.—After ROSE.

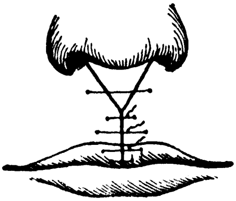

FIG. 555.—Double hare-lip. Appearance of the lip when the operation is completed. — After ROSE.

Some surgeons use silver wire in place of the salmon-gut, but quite as good results can be obtained by the use of the latter, and this substance can be removed much more readily and with less bruising of the tissues. A hare-lip pin is generally quite unnecessary.

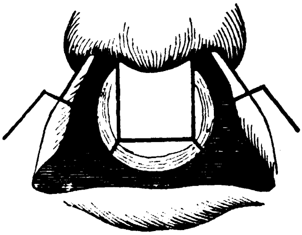

FIG. 556.—Double hare-lip (operation of Maas). Position of incisions at margins of the cleft and on the premaxillary prominence.

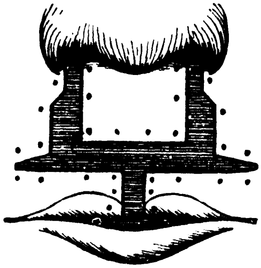

FIG. 557.—Double hare-lip (operation of Maas). Appearance of the parts when the margins of the cleft have been pared. The dots represent the points where the sutures are to be inserted.

(*d*) *Application of dressing.*—The lips and the margins of the united cleft are carefully washed, so as to remove all traces of blood and other débris. Then the lip in the region of the wound is gently sponged with a plug of sterilised wool steeped in absolute alcohol.

The spirit is allowed to evaporate, and then a layer of thin gauze, cut in the shape of an hour-glass, placed on the lip and adjacent parts of the cheeks. The surface of this gauze is painted with collodion, which is allowed to dry. A second sheet of gauze is put on, and collodion applied as before. During the time the dressing is being applied the cheeks are pressed forwards by an assistant, and held in that position until the dressing is quite firm.

After-treatment.—The nurse in charge of the patient should be instructed to pull down the lower lip if necessary, so as to facilitate respiration through the mouth, since it may be impeded by narrowing of the nasal apertures.

On the fourth or fifth day the dressing should be removed, and the salmon-gut sutures taken out. The margins of the wounds are washed, and the dressing re-applied. Three or four days later the dressing is again taken off, all the horsehair sutures taken out, and a dressing applied, which is kept in position by a piece of rubber strapping.

The child will usually be able to suck on the seventh or eighth day—that is, when all the sutures have been removed. Up to this time the milk should be given with a spoon.

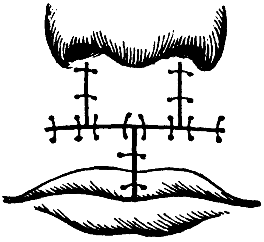

FIG. 558.—Double hare-lip (operation of Maas). Appearance of the lip when the operation is completed.

(*b*) **Double hare-lip.**—In the operation for the radical cure of a double hare-lip, the condition of the intermaxillary bone has much to do with the form of operation, and also with the ultimate success.

The stages of the operation are similar to those in the single hare-lip; the methods of making the incisions, and the appearances presented when the operations are completed, are shown in Figs. 556–558.

Carcinoma of the lower lip.—The most favourable cases of carcinoma of the lower lip for surgical treatment by excision are those in which the disease is recognised at quite an early stage before the adjacent tissues have been infiltrated by the new growth.

Operation.—A V-shaped incision is made in the manner depicted in Fig. 559, each limb of the V being about two-thirds of an inch from the margins of the growth. The entire thickness of the lip is cut through, whilst the apex of the incision should extend down as far as the level of the ramus of the lower jaw. The affected portion of the lip being removed, the divided coronary arteries are picked up and ligatured with catgut. Next the mucous membrane at each side just where it is reflected on to the jaw is incised and the substance of the lip freed for a short distance. This procedure facilitates exact apposition during the subsequent suturing. The margins of the incision are now joined by the insertion of sutures of salmon-gut, each suture passing through the entire thickness of the lip. The mucous membrane of the red portion of the lip should also be sutured by a few points of fine catgut. A second incision is next

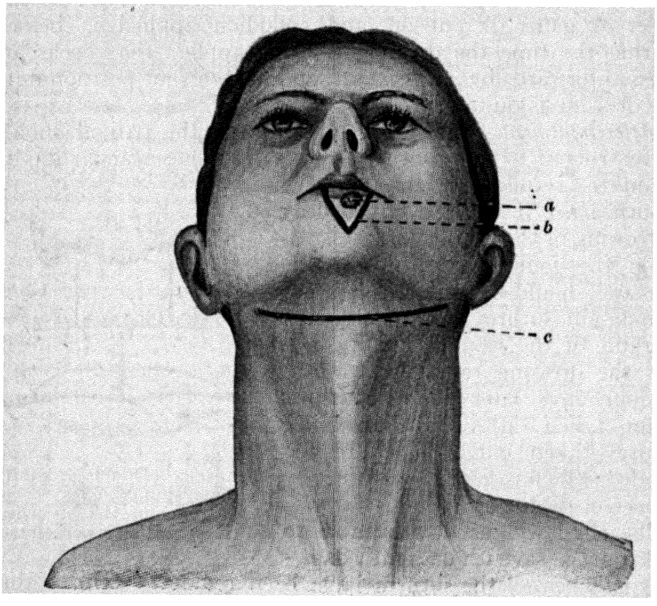

FIG. 559.—Operation for carcinoma of the lower lip.

a. Carcinoma.
b. V-shaped incision.
c. Incision in neck for removal of lymph glands, etc.

made in the position shown in Fig. 559, *c*, and extending from the anterior margin of one sternomastoid muscle to a similar point on the opposite side. The skin is dissected upwards and downwards, and the underlying fascia, submental lymph glands, and submaxillary glands removed in one mass. The margins of this wound are then brought together and fixed in exact apposition by sutures of salmon-gut.

When the growth is more extensive, a rectangular incision should be made sufficiently wide to include all possible infected tissues, and flaps of the skin of the face and neck dissected free. This will enable the margins of the incisions to be brought together. The lymph structures in the neck are removed by an incision similar to that already described.

CLEFT PALATE

A cleft in the palate may involve either a part or the whole of the palatal arch. When the soft palate alone is cleft, the uvula may be simply bifid, or the deficiency may extend as far forwards as the posterior margin of the hard palate. When the hard palate is involved, the portion of the arch which is derived from the palate bones may alone be deficient, or the cleft may extend forwards between the superior maxillæ; while in very extensive cases the cleft passes on one or other side of the premaxillary bones to become continuous with a hare-lip. It only very rarely happens that a congenital aperture in the hard palate is met with, unless associated with a similar condition of the soft palate, since the order of closure is from before backwards.

Apertures in the hard or soft palate, usually the latter, may also be dependent upon disease. These usually follow tertiary syphilitic ulcerations of the palatal region. Before attempting to cure an aperture in the palate which has been caused by tertiary syphilis, it is advisable to give the patient a course of anti-syphilitic treatment. Apertures in the soft palate may be cured by operation, but only in rare instances can perforations in the hard palate be cured.

Period of life at which the operation ought to be performed in cases of congenital origin.—Some surgeons have advocated operation at an early stage, even during the first few weeks of life; but, according to the experience of most authorities on the subject, the end of the second year, when the first dentition is complete, is now considered to be the most favourable time to operate. If the closure of the cleft in the palate is delayed beyond this period, articulation is liable to be interfered with.

There are, however, quite a number of cases when, the patients being strong and healthy, operation during the first few weeks of life is the best.

When the cleft involves the tissues of both the soft and the hard palate, it is advisable to ensure union of the hard palate first; but, if it is possible, the entire cleft should be closed at one operation.

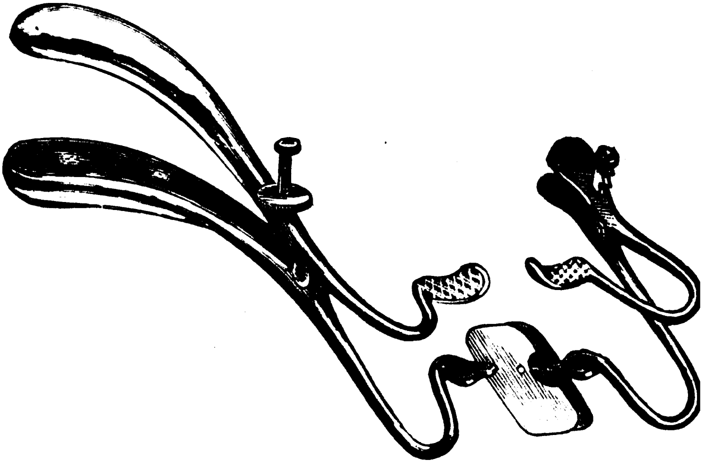

FIG. 560.—Mouth gag for use in operations upon the palate.

Special instruments.— Gag, long-handled tenotome or fine-bladed scalpel, ordinary scalpel, scissors (bent or straight), periosteal elevators, long fine-toothed forceps, palate-hook, needles, needle-holder, suture material (fine silver wire, silk, and horsehair).

Position.—The patient is placed in the dorsal posture on the operation table, with the neck raised by a hard pillow and the head thrown back. The gag (Fig. 560) is introduced, and the mouth thus held open by an assistant. The surgeon stands on the right side of the patient, the assistant on the left side, and the anæsthetist at the head. The assistant, who is administering the anæsthetic, usually looks after the gag.

(*a*) **For cleft of both hard and soft palate.**—The operation may be divided into the following stages, namely—(*a*) Making of lateral incision, and separation of the muco-periosteal portions of the hard palate; (*b*) paring of the margins of the cleft; (*c*) introduction and tying of sutures, and closure of cleft; (*d*) making of further lateral incisions in order to relieve lateral tension.

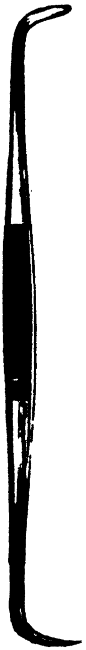

Fig. 561.—Periosteal elevator for separation of muco-periosteal flap.

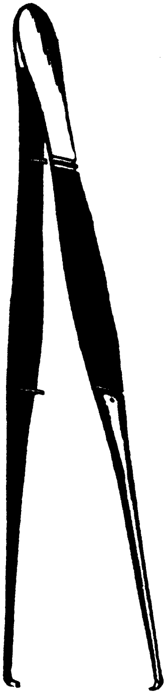

Fig. 562.—Long fine forceps for operations upon palate.

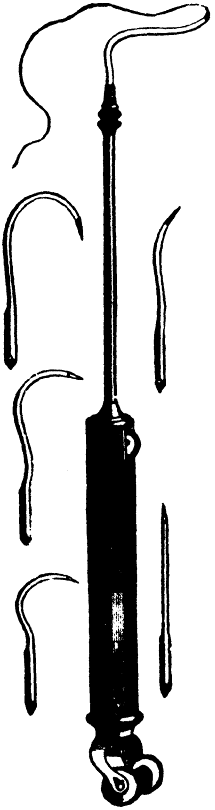

Fig. 563.—Tubular cleft-palate needle.

Operation.—(*a*) *Lateral incision and separation of muco-*

periosteum.—An incision is made through the soft tissues of the palate, commencing at a point internal and opposite to the last temporary molar tooth, and extending forwards parallel with the alveolar margin as far as the anterior border of the canine tooth—that is to say, just in front of the termination of the cleft, except in those cases in which the deficiency extends through the alveolus. The palatal tissues should be incised in a direction perpendicular to the surface, and all bevelling of the margins must be avoided.

Care must be taken to divide everything down to the bone, otherwise one or more of the palatine arteries may be only partially divided, and severe hæmorrhage will ensue, which will be difficult to arrest.

Sponge pressure is applied for a short time, and then the muco-periosteal tissues are separated from their connections with the bony palate with the periosteal elevator (Fig. 561).

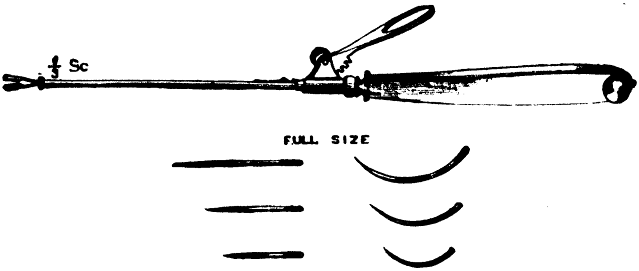

FIG. 564.—Needle-holder and small needles for operation upon palate in young children.—LANE.

The separation of these tissues should be extended until the point of the elevator reaches the margin of the cleft. Great care is necessary in effecting the separation of the soft tissues from the region of the posterior part of the hard palate and the hamular process, owing to their thinness.

The opposite side is treated in a similar manner, and then the second stage can be commenced.

(*b*) *Paring margins of cleft.*—With the long forceps one margin of the cleft is seized a short distance in front of the base of the uvula. The tenotome is now taken, made to pass through the palatal tissue opposite the forceps with the cutting edge looking towards the front, and then a strip of tissue is removed as far as the anterior margin of the deficiency. The line along which this incision is made is shown in Fig. 565.

The forward part of the cut having been made, the edge of the knife is turned backwards, and the remaining part attached to the uvula cut through. A similar procedure is carried out on the opposite margin of the cleft. An attempt should be made, if possible, to remove the two strips attached to one another anteriorly, so as to ensure that the entire margins have been thoroughly pared.

(*c*) *Insertion of sutures.*—Many methods of inserting the sutures have been recommended. The sutures of silk or horse-hair must be introduced by some form of needle with an eye, whilst those of silver wire can be most readily introduced by the needle of Smith, which is illustrated in Fig. 563. In this needle the stem is hollow, and, after the tissues of the palate have been pierced, the wire is driven through the perforation by turning the wheel which is attached to the handle. A very useful and expeditious method of introducing the sutures is by the small

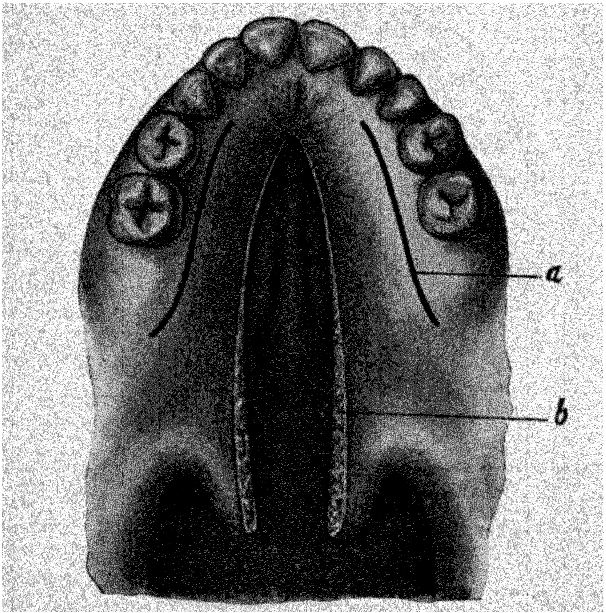

FIG. 565.—Operation for cleft palate. Appearance of the palate when the margins of the cleft have been pared and before the sutures are introduced.

a. Lateral incision. *b.* Pared margins of cleft.

needles and the special form of needle-holder which have been recommended by Lane. These instruments are figured in Fig. 564.

It is best to start from the posterior angle of the cleft in introducing the sutures. When one suture has been inserted it can be used as a point of support in order to facilitate the insertion of the next one. The sutures used to approximate the part of the cleft which corresponds to the hard palate should be of silver wire; and those for the soft palate and the uvula, of fine salmon-gut or horsehair.

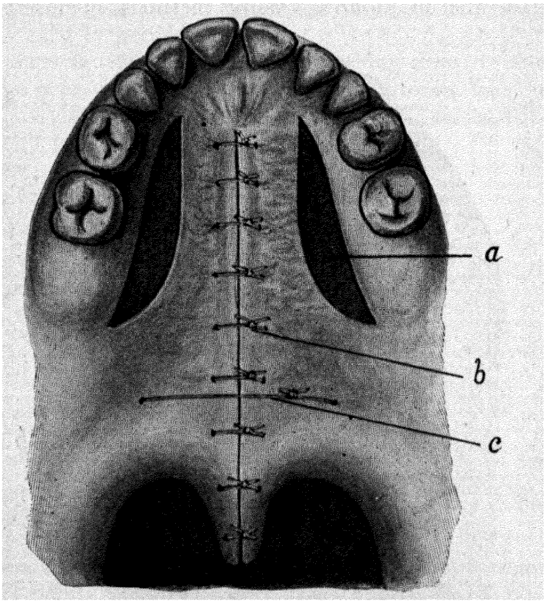

FIG. 566.—Operation for cleft palate. Appearance of the palate when the operation is completed.

a. Space left by separation of margins of lateral incisions.
b. Sutures fixing pared margins of cleft in apposition.
c. Suture for relief of tension.

After the sutures have been inserted, the margins of the cleft should be carefully sponged, so as to remove all blood-clot, mucus, or other débris. The sutures are now tied and their ends cut short. In the case of the wire sutures it is best to twist them with the wire-twister shown in Fig. 567, and then to cut the ends short. The uvula is the last portion of the palate to be closed.

(*d*) *Relief of lateral tension.*—The lateral incision on each side is prolonged backwards for a short distance, and the *tensor and levator palati muscles cut through* on the internal aspect of the hamular process, or the base of the hamular process itself detached at its base by cutting with a small chisel or bone forceps. A probe-pointed narrow scalpel is the best for this purpose. When the incision has been made, the wound should be examined, so as to ascertain that the entire muscle has been cut through.

(*e*) **For cleft of the soft palate.**—The operation for closure of a cleft which involves the soft palate alone is often known as *staphylorrhaphy*, that for closure of the hard palate being called *uranoplasty*.

Operation.—The stages of the operation and the manner of its performance are very similar to those in the preceding operation.

In this case, however, it is usual first to pare the edges of the cleft, then to introduce the sutures, and afterwards to make the lateral incision. The lateral incision is placed farther back, and is made to divide the levator palati muscle. The different stages of the operation are illustrated in Figs. 568 to 570.

After-treatment.—Much of the success of the operations for cleft palate depends upon careful attention to the details of the after-treatment. After the operation has been performed, the patient should be placed in bed with his head low, so that any accumulation of blood, mucus, or exudation may pass into the pharynx, and not collect in the immediate neighbourhood of the wound.

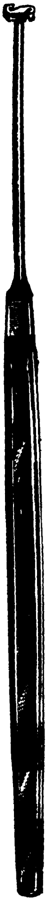

FIG. 567.—Wire-twister.

No food should be given for the first five or six hours, and only small quantities of milk, or milk and soda-water, until all danger of vomiting, as the result of the anæsthetic, has passed off.

After the end of the first day the patient is fed regularly on a fluid diet. The food can be best administered with a spoon, or some form of feeder.

After food has been given, the mouth of the patient should be carefully washed out with a dilute antiseptic, such as a solution of boracic acid or Condy's fluid. In refractory children this cannot as a rule be carried out.

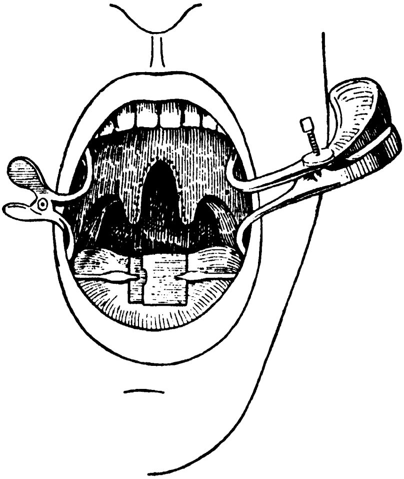

FIG. 568.—Operation for cleft palate. Partial, involving only the soft palate. The dotted line marks the position where the margins of the cleft are pared.

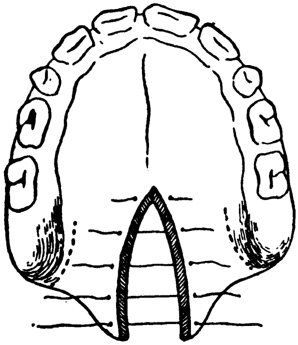

FIG. 569.—Operation for cleft of soft palate. Appearance of the palate when the margins of the cleft have been pared and the sutures introduced.

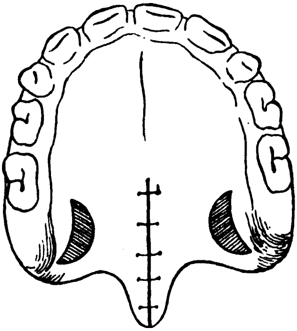

FIG. 570.—Operation for cleft of soft palate. Appearance of the palate when the operation is completed.

The stitches can usually be taken out from the uvula and the soft palate at the end of a week, and those from the hard palate on the tenth or twelfth day. In young children it is generally advisable to give an anæsthetic before removing the stitches.

It is not advisable to give any form of solid food until after the expiration of two or three weeks.

Many modifications of the operation, especially for closure of the hard palate, have been advocated, but the operation above described will be found to be applicable to the majority of cases.

OPERATION FOR EXTROVERSION OF THE URINARY BLADDER, OR ECTOPIA VESICÆ

In ectopia of the urinary bladder the anterior wall is deficient, and most commonly this condition is associated with non-approximation of the pubic bones, epispadias, and often by hydronephrosis.

The urine as it is secreted passes along the ureters and escapes through the ureteral openings, which are situated upon the mucous membrane representing the posterior wall of the bladder. This mucous membrane usually projects as a reddened prominence in the hypogastric region.

The condition of a patient suffering from ectopia vesicæ is a very miserable one, on account of the continuous escape of urine and the difficulty which is experienced in fitting up an apparatus to collect it as it passes from the ureteral openings.

Patients, however, who have been the subjects of this condition have lived to old age without an operation being performed, but usually the patients so afflicted do not live beyond seventeen to twenty-five years.

Two varieties of operation may be performed for the relief of extroversion of the urinary bladder. In one class an attempt is made to form a new anterior wall to the bladder, by turning down and reversing a flap of skin from the umbilical region, the epidermal surface of this umbilical flap becoming the lining membrane of the anterior part of the bladder. Lateral flaps are turned up from the inguinal regions, and used for closing in the cutaneous deficiency. This operation is known as the " flap " operation, or " Wood's operation."

In the second class of operation an attempt is made to bring together the anterior extremities of the pubic bones and fix them in apposition, and at the same time the layer of mucous membrane which represents the wall of the bladder is folded upon itself in front, the margins being united in such a manner that a urinary receptacle is formed, the opening of which is situated below and behind the united pubic bones. In order to effect this result it is usually necessary to divide the sacro-iliac synchondroses behind, and then to force the bones apart in order to approximate the pubic bones in front. The surfaces of the latter are freshened and fixed together.

Flap operations.—By a single umbilical flap and two lateral inguinal flaps ("Wood's operation").—A flap of skin and fascia which is pyriform in shape, the narrow portion being above, is reflected from the umbilical region and turned downwards in such a manner that it remains attached by its lower part (Fig. 571, A); the cutaneous aspect is reversed and forms the anterior boundary of the new urinary bladder. The margins of the mucous membrane of the bladder are refreshed and attached to those of the reversed umbilical flap.

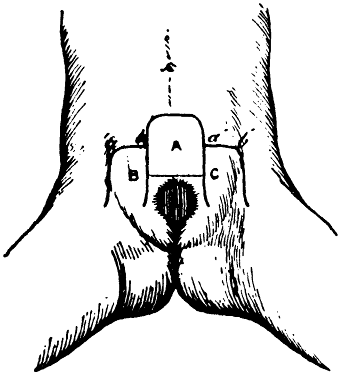

FIG. 571.—Extroversion of the bladder. Formation of skin flaps.—WOOD.

A. Umbilical flap.
B. Right inguinal flap.
C. Left inguinal flap.
a–b and *a'–b'*. Bases of inguinal flaps which come together.

A lateral flap is then taken from each inguinal region; this is also pyriform in shape, but the attached portion is the narrower (Fig. 571, B and C).

Each of these flaps should consist of skin and superficial fascia. The free extremities are rotated medially towards the middle line until their medial and upper margins meet; these are united to one another by the insertion of numerous interrupted sutures. The raw surfaces thus produced are partially closed by bringing the margins of the denuded surfaces together by sutures, the remainder being allowed to close by granulation.

It is usually necessary to perform a number of operations before a moderately satisfactory result can be obtained from this procedure.

The disadvantage of this form of operation is the growth of hair from the cutaneous surface which had been turned inwards.

When this takes place, at puberty or earlier, phosphatic deposits are liable to form, and to give rise to much trouble.

If the mucous membrane which represents the bladder is fairly extensive, an attempt may be made to free the lateral margins, fold them on themselves, and then unite the approximated borders by the insertion of interrupted sutures. If this can be done, a urinary receptacle is formed which is small in size, but its interior is formed entirely of mucous membrane, and the result is likely to be more satisfactory than in the preceding case.

Operations with division of the sacro-iliac synchondroses and approximation of the separated portions of the pubic bones ("Trendelenburg's operation").—The first stage in this operation includes the making of two incisions over the sacro-iliac synchondroses, division of the posterior ligaments of these joints, forcible separation of the sacrum and the iliac bones behind, and approximation of the pubic bones in front. The surfaces of the pubic bones are freshened with a scalpel before they are fixed together.

In the second stage, which is carried out after the wounds caused by the previous stage have healed, the mucous membrane which represents the urinary bladder is folded upon itself, and its margin united in a manner similar to that described above.

In the third stage, an attempt is made to close in the cutaneous deficiency by the formation of skin flaps from the groin and lateral margins of the cleft. The inner margins of these flaps are united together in the middle line.

The epispadias which is commonly present in these cases is treated at a subsequent operation.

An objection which has been urged against this form of operation is that the pelvis is so much weakened by the injury to the sacro-iliac joints that progression is seriously interfered with. This in practice, however, has been found not to be true, since the weakening which takes place posteriorly is in part compensated for by the approximation of the pubic bones in front.

The best result, however, which can be expected in a severe case of extroversion of the bladder is, that it is rendered possible to fit up the patient with an artificial urinal, which catches in a satisfactory manner the urine as it is evacuated, and avoids the continual soaking of the clothing.

OPERATION FOR EPISPADIAS

In the condition of epispadias the penis is cleft along the dorsal surface, and the organ is usually turned towards the abdomen and bent upon itself.

Several operations have been practised for the cure of this condition ; the best of these is the following, which is generally known as " Thiersch's operation " :—

Operation.—The operation is carried out in four stages, the wounds which have been caused in one stage being allowed to heal before the next stage is attempted.

(*a*) FIRST STAGE.—*Formation of external urinary meatus, and glandular portion of penile urethra.*—Two incisions are made in the glans penis from each dorso-lateral aspect, as in Fig. 572. These incisions should pass through more than half the substance of the glans penis, and should converge towards one another on the ventral aspect.

The margins of the median portion are pared, and then fixed in approximation by the insertion of several points of interrupted suture. The middle portion, thus separated, and containing a canal in its interior, is depressed, and the two lateral portions brought together and united by sutures. An aseptic dressing is applied and the wound allowed to heal, the sutures being removed at the end of a week.

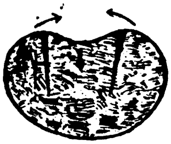

FIG. 572.—Epispadias (" Thiersch's operation "). Incisions into substance of glans penis in formation of the meatus.

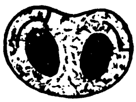

FIG. 573.—Epispadias (" Thiersch's operation "). Incision on dorsum of penis.

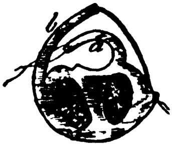

FIG. 574.—Epispadias (" Thiersch's operation "). Method of turning over the skin flaps.

(*b*) SECOND STAGE.—*Formation of that portion of the spongy urethra which occupies the body of the penis.*—Incisions are made through the skin and fascia on the dorsal aspect of the penis, as in Fig. 573. The incision on the left side is nearer the cleft than that on the right. The two flaps thus marked out are dissected up, and the flap with the attached base close to the cleft is turned over, so as to form the roof of the new urethra, and fixed in position. The other flap is then brought over the first one, and fixed by the insertion of sutures (Fig. 574). A catheter is passed along the new urethra and left in position. Dressings are applied and the parts allowed to heal, the sutures being taken out at the expiration of seven or ten days.

(*c*) Third Stage.—*Closure of the small interval between the first and second portions of the new urethra.*—The prepuce is brought over the cleft, an incision made through it, and through this the glans penis is passed. The margins of the aperture are freshened, and united to the skin of the prepuce. A sufficient time is allowed for the parts to heal, and then the final stage is undertaken.

(*d*) Fourth Stage.—*Closure of the aperture at the base of the penis between it and the os pubis.*—This is effected by dissecting up two flaps from the adjacent portions of the inguinal regions. One flap is triangular in shape, and its attached border corresponds to one margin of the orifice which it is wished to close. This flap, after being dissected up, is reversed, and the cutaneous surface made to form the roof of the new urethra. It is fixed in position by the insertion of a number of sutures (Fig. 575). Next, a rectangular-shaped flap is dissected up from the other inguinal region. It is brought over the first flap in such a manner that the two raw surfaces are in approximation. The margins are then united by sutures.

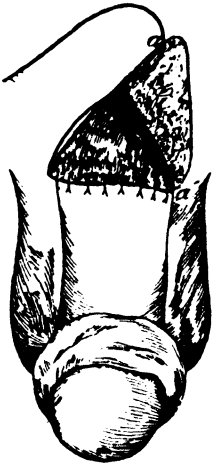

Fig. 575.—Epispadias ("Thiersch's operation"). Closure of fistula between original and newly-formed portions of the urethra. Esmarch and Kowalzig.

A catheter is passed along the entire urethral canal as thus completed, and allowed to remain until union has taken place.

It is advisable that this catheter should be changed daily after the first twenty-four hours.

In order to obtain a good result from this operation, it is advisable to allow plenty of time to elapse between the individual stages, and if one stage fail, to repeat this before going on to the next.

Operation for Hypospadias

In the condition of hypospadias there is a cleft on the under surface of the penis ; this may involve the meatal region alone, or any part of the spongy portion of the urethra as far back as the perineum.

The slighter malformations of this nature scarcely require surgical treatment; but when the penile part of the urethra is cleft, or the scrotum involved, an operation should be attempted for the rectification of the deformity.

Usually the penis is small and deformed, and is bent towards the scrotum, a fibrous band often holding it down.

If an operation is considered advisable, it should be carried out during early childhood, before the fifth or sixth year.

The form of operation which is recommended is that described by Duplay.

Special instrument.—Catheter.

Position.—The patient is placed in the dorsal position on the operation table, the thighs being separated; or, if the scrotum is involved, in the lithotomy position. The surgeon stands on the right side of the patient, and the assistant on the opposite side.

Operation.—The operation may be divided into the following stages, namely:—

(*a*) *Straightening the penis.*—This is effected by making one or more transverse cuts through the fibrous band which fixes the under surface of the penis to the scrotum. It is often necessary to extend these incisions into the substance of the corpora cavernosa.

(*b*) *Formation of an external meatus.*—An incision parallel with the long axis of the penis is made on each side of the groove which represents the urethral canal on the under surface of the glans penis. A catheter is placed in the groove, and the tissues at the margin of each incision are turned over the catheter and fixed thus by the insertion of sutures. Next, the tissues at the outer margins of the incisions are freed for a short distance and brought over the new meatus, and sutured in this position.

The straightening of the penis and the formation of the meatus are performed at the same time. Sufficient time is allowed for these wounds to heal, and then the next stage is carried out.

(*c*) *Formation of a urinary canal.*—A catheter is passed through the new meatus and along the groove on the under surface of the penis into the original opening of the urinary canal. An incision parallel with the catheter is then made on each side of the groove and a short distance from it, and a small transverse incision along each extremity of the long one. A small flap is then dissected up for a short distance on each side, and turned over the catheter in such a manner that the cutaneous surface lies in contact with it. It is not necessary that the margins of these two flaps should be in apposition over the catheter. The tissues at the external margin of each longitudinal incision are next dissected up very freely until these margins can be brought into approximation on the ventral aspect of the catheter, which lies in the urethral groove. The approximated borders of the external flaps are fixed in apposition by the insertion of a series of interrupted sutures.

A sufficient time is now allowed to elapse until the flaps thus united have become quite healed.

(d) Closure of the fistula between the distal extremity of the old urinary canal and the proximal extremity of the new one.—The margins of the fistulous aperture are pared, and if necessary a flap of skin is dissected up from the adjacent portion of the penis. This is brought over the aperture and fixed by sutures.

SKIN GRAFTING

This procedure may be requisite in cases of extensive destruction of the skin, the result of a burn or scald, or some form of injury or ulceration, or of a surgical operation carried out for the removal of a malignant growth.

Skin grafting by the punctuate or ordinary method.—The surface upon which the grafts are to be placed is first rendered as aseptic as possible by fomentations or other measures; then, with a pair of fine forceps and scissors, small portions of the skin are removed by sharp snips from a healthy cutaneous surface, and placed upon the prepared surface. Each graft of skin should be about one-sixth of an inch wide, and should include both the epidermis and the superficial part of the dermis.

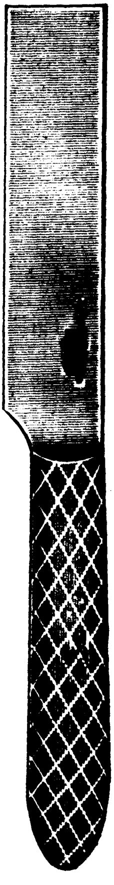

FIG. 576.—Skin grafting. Thiersch's knife.

These grafts are placed at equal distances apart, usually about one-third or one-half inch from each other. A perforated piece of oiled silk is then placed over the grafted area, and a dressing applied. The wound thus treated should not be disturbed for several days, unless there is much exudation from its surface.

When the dressings are removed, the surface should be very gently washed with saline solution, or sponged and dried, and then a similar dressing or ointment applied.

Skin grafting by epidermal strip or "Thiersch's method." The essential feature in this method of skin grafting is the transference of large sheets of epidermal tissue from a healthy part to the surface of the wound which has lost its cutaneous covering.

The strips of epidermis should measure 1 or 1½ inches in width, and from 2 to 3 inches in length. They can be most readily obtained from the internal aspect of the thigh.

A special instrument, known as Thiersch's knife (Fig. 576), or an ordinary razor, is used for the purpose of making these epidermal strips.

The skin of the area, from which it is proposed to obtain the epidermal strips, is rendered aseptic in the usual manner. Then the blade of the knife is moistened with normal saline solution at the temperature of the body, and a thin shaving made, the blade of the knife being held on the flat. Each strip should consist of the epidermis and the apices of the underlying papillæ; it ought to be not less than ½ inch wide, and 2 inches or more long. Care must be taken not to injure the sub-epidermal tissues in obtaining the epidermal strips.

When a strip of epidermis has been obtained, it is placed on the prepared surface, and when the whole of the raw surface has been covered, dressings are applied as in the previous case.

CHAPTER XXXII

OPHTHALMIC OPERATIONS

BY

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General considerations.—It is convenient to mention, in the first place, certain general principles which are common to many of the operations on the eye, in order to avoid a repetition of them in the description of each operation.

The ophthalmic surgeon should, for all purposes of operating, be strictly ambidextrous, so that the operation on the left eye should be in every way a mirror picture of that on the right eye, and consequently the description of the operation on the right eye here given only needs transposing in every particular to be true for the left eye.

The patient lies on his back with the head slightly raised; the surgeon in most cases stands immediately behind the patient's head, and the assistant on the side of the eye to be operated on, facing the surgeon.

A really good focussing electric lamp for projecting light upon the eye is of the first importance, and in addition, in intra-ocular operations, a large convex lens is manipulated by the assistant, so as further to focus the light on the part of the eye required.

Preparation of instruments.—This does not differ essentially from the preparation of other surgical instruments, except that they are so delicate, that if the great annoyance is to be avoided of finding in the middle of an operation that an instrument is defective, the surgeon will be wise to see to the choice and preparation of them himself, unless a nurse skilled in ophthalmic practice is available.

It is safest to boil all instruments; two minutes is enough for the knife, as prolonged boiling dulls its edge, the other instruments should be boiled for five minutes; they are placed on a dry towel and used dry.

The points and edges of the cutting instruments are tested on a piece of thin kid stretched over a drum, they should penetrate this when laid across the fingers without being held; scissors are tested on the thin pulled-out edge of a piece of cotton wool. It is most important to be satisfied about the keenness of the whole length of the cutting edge of the knife, and not to be satisfied because the point is good.

Preparation of the patient.—This should be carried out exactly as for any other operation.

Preparation of the eye.—It is obvious that the conjunctival sac cannot be rendered sterile by the methods that are used for other parts, and it has to be remembered, that should acute infection follow an intra-ocular operation, loss of the eye almost invariably follows. Before operating, therefore, the lids, conjunctiva, and lachrymal sac should be examined, and in the case of operations for cataract a bacteriological examination should be made. If the xerosis bacillus of the *Staphylococcus epidermidis albus* is present it may be ignored, but if other organisms are present the operation should be postponed, and a course of irrigation with antiseptic lotions be prescribed. When such cases come to operation later, it is wise to irrigate the conjunctival sac on the table with 1 in 2000 perchloride of mercury solution.

Anæsthetics.—All intra-ocular operations in adult patients are best done under a local anæsthetic, for the risk of post-anæsthetic vomiting, with its attendant danger of intra-ocular hæmorrhage or expulsion of the vitreous, is thus avoided. If, however, the eye is acutely inflamed as in acute glaucoma, cocaine is but little absorbed and efficient anæsthesia is not obtained. In these cases, if a general anæsthetic is seriously contra-indicated, novocain can be used. If a 4 per cent. solution is injected under the conjunctiva and into Tenon's capsule, an iridectomy for acute glaucoma can be performed, and if it be injected well back into the orbit with a long needle, even an inflamed eye can be excised with little or no pain.

Of general anæsthetics chloroform is best on account of the quieter anæsthesia obtained; laboured breathing, with its attendant movement of the head, adds to the difficulties of the delicate manipulations in an intra-ocular operation.

OPERATIONS

Excision of the Lachrymal Sac

Indications.—Cases in which permanent obstruction of the nasal duct is accompanied by distension of the sac with mucus, muco-pus, or pus.

Special instruments.—A stiff narrow-bladed knife, a speculum wound retractor (Fig. 577), and a blunt dissector.

Anæsthetic.—Unless the tissues are acutely inflamed, novocain anæstjesia is much the best.

Operation.—The surgeon stands on the side to be operated on and facing the patient. There are two important guide structures, both of which can usually be seen through the skin before the incision is made; they are the angular vein and the internal palpebral ligament. A curved incision is made over the sac, commencing half an inch above the ligament; it then passes downwards between the angular vein and the inner canthus, and follows the orbital margin for about an inch. The retractor is now inserted and the wound deepened till the palpebral ligament is defined, immediately deep to this structure the smooth sac wall will be found. The sac wall is now kept in view the whole time, and to this end efficient swabbing is essential. Having exposed the sac from the ligament down to the beginning of the nasal duct, the chief part of the rest of the separation can be effected with the blunt dissector. The separation is easiest at the inner side; a little difficulty is experienced with the fundus of the sac owing to its being attached to the periosteum by a few bands of fibres, and to its protruding a short distance upwards under the ligament (there is not the slightest need to divide this ligament except when repeated abscesses have formed in connection with the sac). The outer side offers a little difficulty where

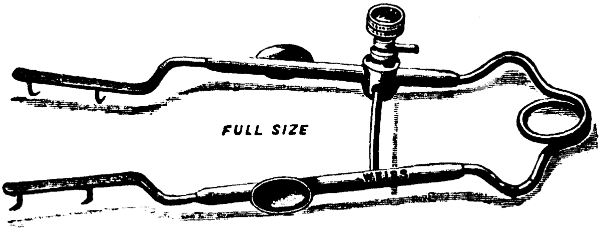

Fig. 577.—Speculum wound retractor.

the canaliculi enter the sac. Having cleared the sac to a point a short distance down the nasal duct, it is gripped in a pair of Spencer Wells forceps and twisted round and round, as if twisting an artery, and so dragged out. The wound is closed with horsehair sutures and a graduated pressure pad applied: a drain is unnecessary.

PTOSIS OPERATION

Indications.—

(*a*) Congenital ptosis.

(*b*) Slow progressive ptosis of adults without other ocular palsies.

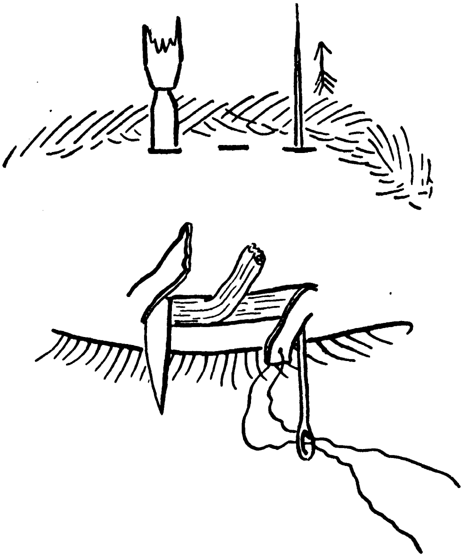

FIG. 578.—Operation for ptosis.

(*c*) A few cases of Myasthenia Gravis of chronic progress.

(*d*) Some traumatic cases.

There are three groups of cases, each requiring its own particular operation:—

(1) Those in which a levator muscle is present.

(2) Those in which there is no levator, but the superior rectus is present.

(3) Those in which neither of these muscles is present.

1. The best procedure is to expose the expansion of the weakened muscle by a skin incision about three-quarters of an inch above the lid margin, clear the anterior surface of the tarsal plate down to the lid margin, and sew the expansion of the levator to the front surface of the tarsal plate as low down as possible, tying the sutures over fine rubber tubing just above the lashes.

2. In this group the first procedure is to pass a silk suture through the highest part of the superior fornix on each side. These sutures are then pulled upon and the eyelid is thus turned inside out. The conjunctiva between the sutures is divided in a horizontal plane, the conjunctival tissues and Tenon's capsule exposed and divided, and the superior rectus defined. One-half of this muscle is now freed from its attachment to the globe, and the muscle then split along its length into two equal portions; the one part is left attached to the eyeball, a suture is passed through the extremity of the detached half and this portion is sewn on to the front of the tarsal plate, the suture being brought out through the skin just above the lashes and tied as before over a small piece of rubber tubing.

3. In this group neither the levator nor the superior rectus muscles are present, and the frontalis is made use of to raise the lid.

Special instruments.—A von Graefe's knife, Beer's knife, and a long straight needle.

Operation.—A strip of skin and tissues down to the orbicularis is isolated (Fig. 578). This strip is placed about 4 mm. above the lid margin, and extends for about the middle two-fourths of the lid; it is divided into two at its middle point. This strip is best cut with a Beer's knife by transfixion; the upper incision should be a little longer than the lower. A third strip is now cut from the exposed orbicularis, having its base at the centre of the wound, so that it, like the skin strips, is one-half the length of the incision. A von Graefe's knife is now passed from just below the eyebrow, amongst the tissues of the lid, and is made to emerge through the wound, at the base of the strips (Fig. 578). Without removing the knife a long straight needle is passed from above, eye first, the knife being used as a director. A silk stitch is passed through the end of the strip, both its ends are threaded through the needle's eye, and the stitch, followed by the strip, is dragged through the track made by the knife and is thus brought out just below the brow. It will be found that a considerable length of the strips can be pulled through the upper incision, and they are fixed there by a single silk stitch which passes through the lower lip of the wound. The other two strips are treated similarly, and the original incision is closed neatly by fine hair stitches. It will be found that the effect produced tends to increase rather than to decrease.

OPERATION FOR ENTROPION WITH TRICHIASIS

Indications.—Any case, whatever the cause, in which recurrent ulceration of the cornea results from the irritation of inturned lashes.

Anæsthesia.—A general anæsthetic is best.

Special instruments.—A Beer's knife.

Operation.—An incision, extending beyond the affected area of the lid and about ⅛ inch in depth, is made in the inter-marginal space, so as to divide the lid into an anterior part composed of skin and orbicularis and containing the hair follicles, and a posterior part containing the tarsal plate. In order now to displace the hair-bearing portion upwards out of reach of the cornea, an elliptical portion of skin is removed (Fig. 579), the lower incision being parallel with the lid margin and about 4 mm. above it. When now this incision is closed by sutures, the hair-bearing anterior portion of the lid is swung upwards, and the lashes are thus drawn away from possible contact with the cornea (Figs. 580, 581). The raw surface may now be left to granulate, or it may be covered by the portion of skin which was removed. This skin readily grows on to the surface if it is accurately placed ; the hairs contained in it, however, come into contact with the cornea, and though they are exceedingly fine, they are enough to cause irritation.

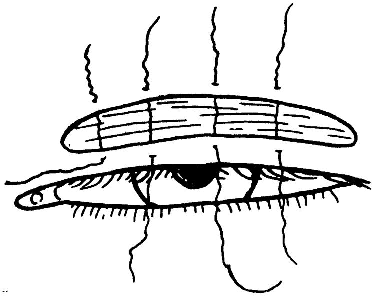

Fig. 579.—Operation for entropion.

A valuable modification is to cover all that is possible of the raw area by means of a pedicled conjunctival graft. A strip of the ocular conjunctiva is cut from below the cornea, leaving it attached at one end by a pedicle. This strip is applied as accurately as possible to the raw area, and fixed in position by three or four fine stitches ; both eyes are bandaged.

After forty-eight hours the base of the pedicle is divided, the resulting free cut end of the flap being adjusted on to the raw area and fixed by a fresh stitch if necessary. If the whole raw area cannot be covered, the central portion should have preference. A strip below the cornea is chosen because when the eyes are closed the eyeballs are rolled upwards, and in this position the base of the pedicle will be in the most convenient position, *i.e.* opposite the palpebral fissure. The patient must be warned against any attempt at opening the eyes till the pedicle is cut through, for any such attempt is accompanied by a downward rotation of the eyes by which the graft is in danger of being torn from its bed.

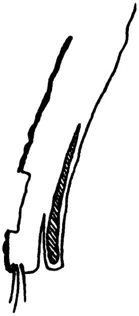

FIG. 580.—Operation for entropion.

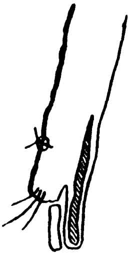

FIG. 581.—Operation for entropion, showing eversion of lashes.

CICATRICIAL DISTORTION OF THE LIDS

In many of the cases of distortion of the lids which result from cicatricial contraction, the deformity can be much ameliorated by means of Esser's grafts. We may take as an example, the cicatricial drawing up of the upper lid, with extropion (Fig. 582). An incision is made to about one-half the depth of the tissues of the lid through the cicatrised area and into healthy tissue on each side; the superficial tissues are undermined for a short distance at each end. The bottom of the incision is now extended in a plane parallel with the surface of the lid (Fig. 583), so that a potential cavity is formed in the substance of the lid. A piece of dental wax (Stent wax) is now moulded in hot water of such a size and shape that it fits rather tightly within the cavity when the edges are brought into apposition, and extends a little beyond the incision into the undermined ends. This wax mould is now completely clothed by a Thiersch's graft with its raw surface outermost, is introduced into the cavity, and the incision accurately closed by fine sutures (Fig. 584). The skin of the flexor aspect of the forearm is of suitable texture for the graft. A few folds of gauze kept moist by normal saline solution form a comfortable dressing.

The wound is left untouched for ten days; the stitches are then removed, the incision opened up, the wax exposed for the whole length of the incision and removed. A cavity, completely lined with epithelium, is thus opened up to the exterior, and adds largely to the superficial surface of the upper lid (Fig. 585). The large surface at first obtained contracts a good deal subsequently, and for this allowance has to be made. It is helpful in some cases to sew a portion of the lids together, either temporarily or permanently, as an adjunct to this operation.

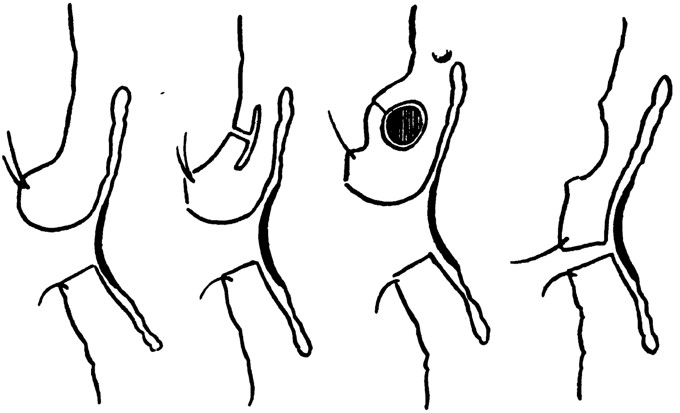

FIG. 582. FIG. 583. FIG. 584. FIG. 585.

Operation for cicatricial distortion of the lids.

Tenotomy of the Internal Rectus

Indications.—Tenotomy of the external ocular muscles is seldom done for any condition other than the concomitant squints, and as these are most often of the internal variety, it is the internal rectus muscle which is most often divided. The chief value of the operation is as an adjunct to shortening and advancement operations on the external rectus.

Anæsthetic.—Cocaine.

Operation.—A vertical incision is made with scissors through the conjunctiva, over the insertion of the muscle. (A convenient way of remembering the point of insertion of the muscles, starting with the internal rectus, is indicated in Fig. 586). A pair of toothed forceps are introduced into the wound and a firm grip is taken of all the tissues down to the globe. The tissues are then snipped through with scissors between the forceps and the underlying sclerotic, and, without loosening the grip, a stitch is passed through the included muscle. This stitch is then passed through the stump of the muscle and is tied quite loosely; its object is to prevent the muscle from retracting so far as to lose all attachment to the eye. The conjunctiva is sewn together.

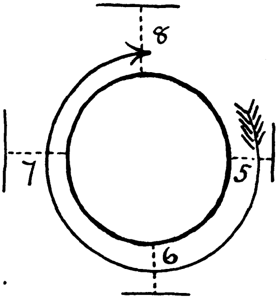

FIG. 586.—Diagram representing points of insertion of eye muscles of right eye, showing millimetres between cornea and muscle insertion.

SHORTENING OF THE RECTI MUSCLES WITH ADVANCEMENT

Indications.—This operation is performed most frequently upon the external rectus to overcome an internal concomitant squint; in cases of high degrees of squint a tenotomy of the internal rectus with a retention stitch is sometimes combined with it.

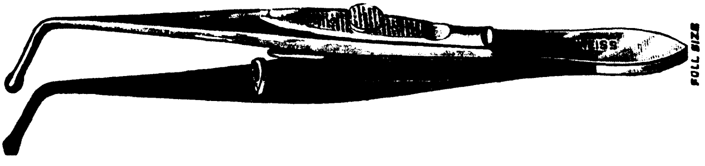

FIG. 587.—Clamp forceps.

Anæsthesia.—In small children a general anæsthetic is necessary, but in older children cocaine is sufficient.

Special instruments.—Clamp forceps (Fig. 587), strabismus hook, small straight cutting needles, Beer's knife.

Operation.—A quadrilateral-shaped flap is turned outwards beyond the insertion of the muscle (Fig. 588). The flap is best cut with a Beer's knife by transfixion, and the same instrument is used in turning back the first portions of the flap, in order to get the sclerotic here quite clean of subconjunctival tissues, so that in the delicate procedure later of passing the stitches through the sclerotic, one can see exactly how much of the sclerotic is being taken up by the needle, and so can be sure of getting a good grip of this coat without penetrating it. The completion of the resection of the flap is effected with scissors, the insertion of the muscle is exposed, and the muscle itself cleared for some distance back. The muscle is clamped in clamp forceps (Fig. 589) and divided in front of them (Fig. 590). Three stitches of silk

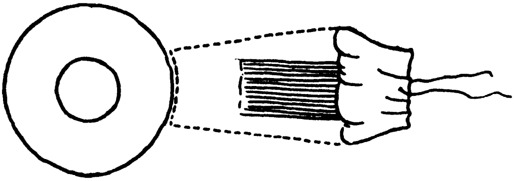

Fig. 588.—Shortening of rectus muscle with advancement. Operation on the right eye as seen from behind the patient's head. Stage I.

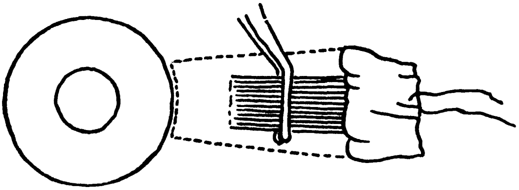

Fig. 589.—Shortening of rectus muscle with advancement. Stage II.

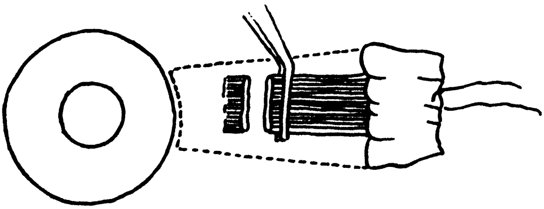

Fig. 590.—Shortening of rectus muscle with advancement. Stage III.

are passed through the edge of the conjunctival flap, and then through the muscle as far back as the degree of squint seems to require (Fig. 591). The clamp with the included muscle is now cut off well in front of the stitches. The upper and the lower stitches are made to traverse the muscle three times so as to get a good hold of it (Fig. 592). The small fully curved needles are now replaced by straight needles with a cutting edge, a grip of the stump of the muscle is taken with toothed forceps, and the stitches passed through the sclerotic close to the corneal margin, about the superficial half of the thickness of the sclerotic being included in their grip (Fig. 593). The stitches are tied, and both eyes kept bandaged for ten days.

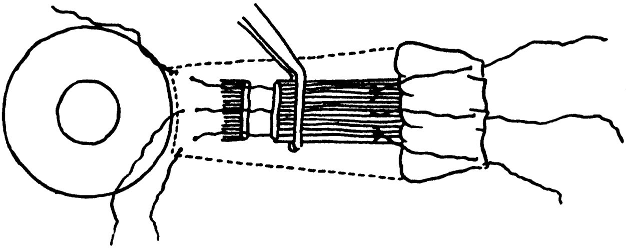

FIG. 591.—Shortening of rectus muscle with advancement. Stage IV.

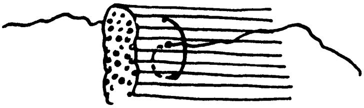

FIG. 592.—Shortening of rectus muscle with advancement. Introduction of suture.

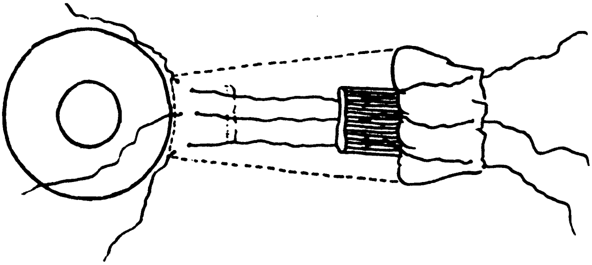

FIG. 593.—Shortening of rectus muscle with advancement. Stage V.

EXCISION

Indications.—

(*a*) Malignant growths.

(*b*) Some perforating injuries.

(*c*) Eyes which in addition to being blind are painful.

Anæsthesia.—Chloroform. If necessary, all but acutely inflamed eyes can be removed after the injection deeply into the orbit of 4 per cent. novocain solution.

Special instruments.—A strabismus hook and a glass globe.

Principles to be had in mind.—1. To preserve all the conjunctiva by cutting it as close as possible to the cornea: it is this membrane which is to line the socket.

2. To cut the nerve as close to the back of the globe as possible and so help to obviate a sunken socket; in cases of malignant growths, and especially of gliomata which spread back along the nerve, the nerve must be cut as long as possible.

3. To put a glass globe in Tenon's capsule in all suitable cases.

Operation.—The conjunctiva is snipped all round as close as possible to the cornea, and is then freed from the underlying muscles and Tenon's capsule as far back as possible. The four recti muscles, with the intervening portions of Tenon's capsule, are picked up in turn on a strabismus hook and divided close to the globe. A pair of flat curved scissors are next introduced at the outer side and the nerve divided. The eye will now come forward, the two oblique muscles are snipped through, and the eye removed. If it is thought inadvisable to insert a glass ball the dressings are now applied.

Insertion of the glass ball.—After the bleeding has nearly stopped, a glass ball of suitable size is made to take the place of the eye. (If water or steam is seen inside the ball it should be discarded.) The cut edge of the muscles and Tenon's capsule is picked up with forceps and a purse-string suture of No. 1 silk is inserted all round. When this suture is tied the ball should be entirely hidden; if any part of it, however small, is exposed, the ball will inevitably be extruded. This suture is cut short and buried. The cut edge of the conjunctiva is now treated in a similar manner and dressings applied.

EVISCERATION

In the operation of enucleation the subarachnoid space of the nerve sheath is opened up, so that a direct communication is established between the cerebral subarachnoid space and the orbital tissues, consequently in cases of panophthalmitis, or where the orbital tissues are acutely infected, there is some danger of the infection spreading along this space to the cerebral meninges. In such cases, therefore, it is safest to cut away the cornea with scissors, and then to remove the whole of the contents of the globe, leaving only the sclerotic. Especial care must be taken that the whole of the uveal tissues are removed so as to avoid any possibility of sympathetic ophthalmia. The tissues are much slower in healing than after enucleation.

IRIDECTOMY

Two types of this operation need to be described, the large iridectomy done for acute glaucoma, and the small iridectomy for several other conditions.

For acute glaucoma.—*Anæsthesia.*—A general anæsthetic is essential.

Special instruments.—It is convenient to enumerate a set of instruments which it is desirable to have at hand in any intra-ocular operation.

1. Speculum.
2. Two pairs of toothed conjunctival forceps.
3. A pair of small, straight, sharp-pointed scissors.
4. De Wecker's iris scissors.
5. Iris forceps.
6. Curette, and
7. Two repositors.

Operation.—A corneal section is made with an attached conjunctival flap exactly as for cataract extraction (*q.v.*) but smaller in size. A grip of the iris, which will be protruded through the wound owing to the increased intra-ocular pressure, is taken with iris forceps at the outer angle of the wound ; it is slightly dragged upon and is then cut through with de Wecker's iris scissors at the outer limit of the corneal wound, to the outer side only of the forceps. The iris, still in the grip of the forceps, is torn away through its narrow root, much as stamps are torn along the lines of perforation, till the inner end of the incision is reached. Now again, as at the outer side, the iris is dragged upon and then cut through at the extreme inner end of the wound. The object of dragging upon the iris as described is to put the intra-ocular portion under tension, so that when the section of the iris is made, the cut edge springs back into the anterior chamber clear of the wound. If the cut edges of the iris are caught on the lips of the incision they are stroked into position by means of the iris repositor, the conjunctival flap is smoothed over the wound, and dressings applied.

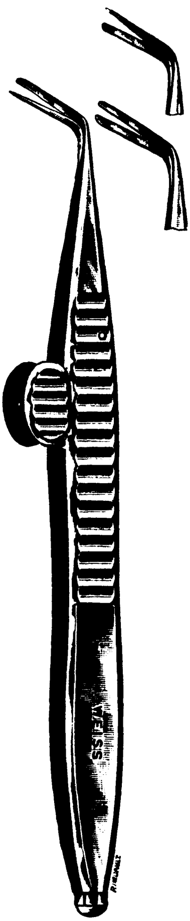

FIG. 594.—de Wecker's scissors.

Iridectomy for conditions other than glaucoma.—*Indications.*—

(*a*) For optical reasons in cases of dense central corneal nebulæ.

(*b*) For complete ring posterior synechiæ.

Anæsthesia.—Cocaine is usually sufficient.

Special instrument.—A keratome.

Operation.—An incision at the corneoscleral junction is made with the keratome opposite a clear part of the cornea in optical cases, at the upper part in other cases. Iris forceps are now introduced closed, through the incision, and a grip is taken of the iris, which is then pulled through the wound and the contained portion snipped off with de Wecker's scissors (Fig. 594), the cut being made in a direction radiating from the centre of the cornea. The cut edges of the iris are replaced into the anterior chamber with the repositor and dressings applied.

THE REMOVAL OF CATARACTS

There are two entirely distinct methods of getting rid of an opaque lens : the one is by breaking it up *in situ* and allowing the lens substance to become absorbed, the other is to remove the lens from the eye by an open incision. The former method is only applicable in subjects below middle age ; after this time the lens is too hard to be dealt with in this way.

DISCISSION OF A CATARACT

Indications.—

(*a*) Congenital cataracts.

(*b*) Traumatic cataracts in young subjects.

Anæsthesia.—Cocaine.

Special instrument.—A Bowman's needle.

Operation.—The pupil is fully dilated by a mydriatic. The needle is made to engage the conjunctiva a quarter of an inch behind the corneo-scleral junction, and, lifting this membrane forward, is made to enter the anterior chamber. By this procedure the puncture in the conjunctiva and that in the cornea do not afterwards overlie each other. The anterior capsule is now incised and the front part of the lens broken up. The aqueous by this means gains access to the interior of the lens, the lens becomes swollen, and as a flocculent mass comes forward into the anterior chamber and is in the course of a few weeks absorbed. A second or a third needling is sometimes necessary. When the whole of the lens matter is absorbed, the remaining posterior capsule of the lens is divided with a sickle-shaped knife (Ziegler's knife).

EXTRACTION OF CATARACT

There are many modifications of this operation ; the following, however, will be found to be the best :—

Indication.—Cataract occurring in patients in the latter half of life.

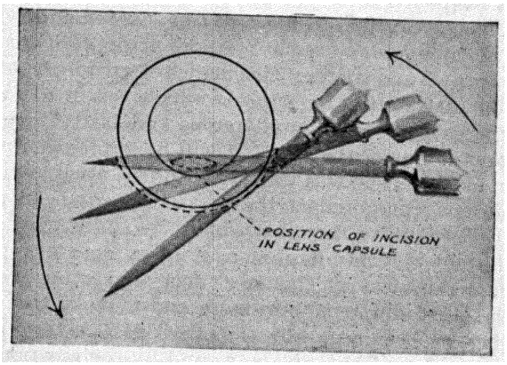

FIG. 595.—Operation for cataract.

Anæsthesia.—Cocaine.

Special instruments.—A von Graefe's cataract knife and a cataract scoop.

Operation.—(*N.B.*—The less the patient is spoken to the better, it is seldom necessary to say more than " Look down, please " ; the operation can often be completed before the patient realises that any but the preliminary manipulations are being carried out.)

The pupil must be fully dilated by homatropine and cocaine. A grip of the conjunctiva and subconjunctival tissues is taken with fixation forceps at a point just below the corneal margin. The cataract knife is entered just behind the corneo-scleral junction at ten o'clock, and is passed onwards till the point has reached the dilated pupillary aperture. The point of the knife is now made to dip so as to pick up the anterior capsule of the lens, the knife at the same time being passed steadily towards the opposite side. As the iris on the opposite side is approached the knife point is raised so as to clear it, and a counter puncture is made corresponding with the point of entry of the knife. The knife is pressed steadily onwards, the point being carried upwards all the time, until by the time the whole length of the blade has been used up the section is almost complete (Fig. 595). If the section is made by to and fro movements of the knife, the iris is apt to wrap over the blade and thus to be buttonholed in cutting out; this will not happen if the above method of using the knife is made use of. Having now cut out along the line AB, the knife is still deep to the conjunctiva, and a liberal apron-like flap is fashioned from the conjunctiva as the knife cuts out. This flap is most valuable for covering the wound when the operation is complete. Pressure is now made with the curette below the cornea, and the lens thus made to extrude, first through the incision in the anterior capsule which was made with the knife, next through the dilated pupil, and lastly through the incision, and so out of the eye. It will be appreciated that the expression of the lens in this way is dependent upon the integrity of a diaphragm composed of the posterior capsule of the lens, continued all round to the ciliary body by the suspensory ligament of the lens. If this diaphragm is incomplete, or is ruptured during the manipulations, the only effect of exerting pressure to express the lens, is to evacuate more and more of the vitreous. The lens having been removed, the upper part of the iris, which has been carried out through the wound by the escaping lens, is replaced with the repositors. The iris forceps are now introduced, and a small portion of the base of the iris is caught hold of, drawn through the wound, and snipped off. The iris is again replaced, the apron-like conjunctival flap is smoothed over the incision, atropine instilled, and both eyes bandaged. The object of the buttonhole iridectomy is to prevent prolapse of the iris; it acts as a safety-valve through which the recurrent gushes of aqueous can escape, before the wound is finally sealed, without carrying the iris through the incision in the process. If this is not done, a prolapse of the iris occurs within the first forty-eight hours in not less than 10 per cent. of cases. The posterior capsule frequently requires incision when the eye is recovered from the primary operation.

SCLERO-CORNEAL TREPHINING

Indication.—Chronic glaucoma.
Anæsthesia.—Cocaine.

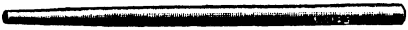

FIG. 596.—Sclero-corneal trephine.

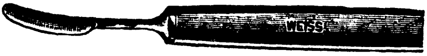

FIG. 597.—Curved blunt-pointed knife.

Special instruments.—A sclero-corneal trephine of 1·5 mm. diameter (Fig. 596) and a curved blunt-pointed knife (Fig. 597).

The object of the procedure is to provide a permanent communication between the anterior chamber and the subconjunctival space, in order to relieve the heightened intra-ocular pressure which is the essence of this disease.

Operation.—A curved conjunctival incision is made above the cornea (Fig. 598). A track is now made under the conjunctiva (to the extent of the shaded area, Fig. 598) by snipping with scissors as far as the corneal margin; it is not necessary to reflect the flap completely, as the lateral tissues can be stretched and displaced sufficiently to get at the cornea. Having reached the corneal margin the dissection is now carried on by means of the knife, so as to extend the flap, composed for the moment of conjunctiva only, into the cornea so far, that the trephine when applied will open into the anterior chamber in front of the root of the iris. It will be appreciated that a small portion of the base of the flap is composed of the superficial layers of the cornea. Having made sure that the dissection has been carried sufficiently far for the trephine to enter

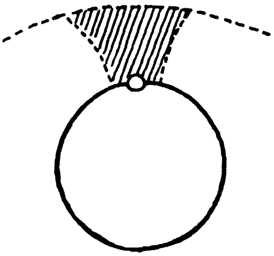

FIG. 598.—Sclero-corneal trephining. Conjunctival incision.

the anterior chamber cleanly, the corneo-conjunctival flap is held down over the cornea, and the trephine applied with its upper end tilted a little towards the centre of the cornea (Fig. 599). The reason of this tilting is, that it is only by chance that the trephined disc of corneo-sclerotic is cut through evenly all the way round and so comes away as a free disc. It is usually hinged outwards —being incompletely cut at some part of its circumference—by the prolapse of the iris as the aqueous escapes when the anterior chamber is opened (Fig. 600). It is desirable that it should hinge upwards so that its base is away from the base of the conjunctivo-corneal flap and can be cut through without endangering the base of the latter. Having removed the disc, the extruded knuckle of iris is cut away, and the rest of the iris then falls back into position inside the eye. The conjunctival flap is now smoothed down and the cut edges of the conjunctiva are sewn by means of fine silk so as to make the

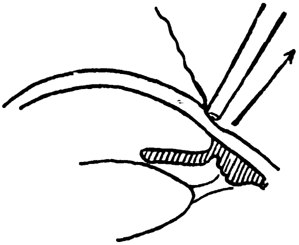

FIG. 599.—Sclero-corneal trephining. Application of trephine.

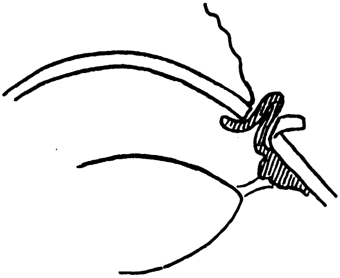

FIG. 600.—Sclero-corneal trephining. Prolapse of iris.

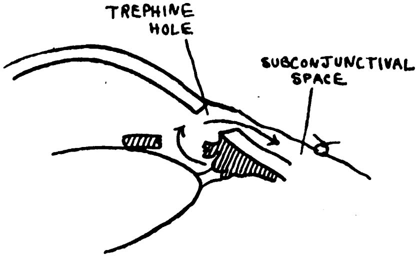

FIG. 601.—Sclero-corneal trephining. Operation completed.

wound water-tight, atropine is instilled, and both eyes are bandaged. It is wise to keep the other eye under eserine for a

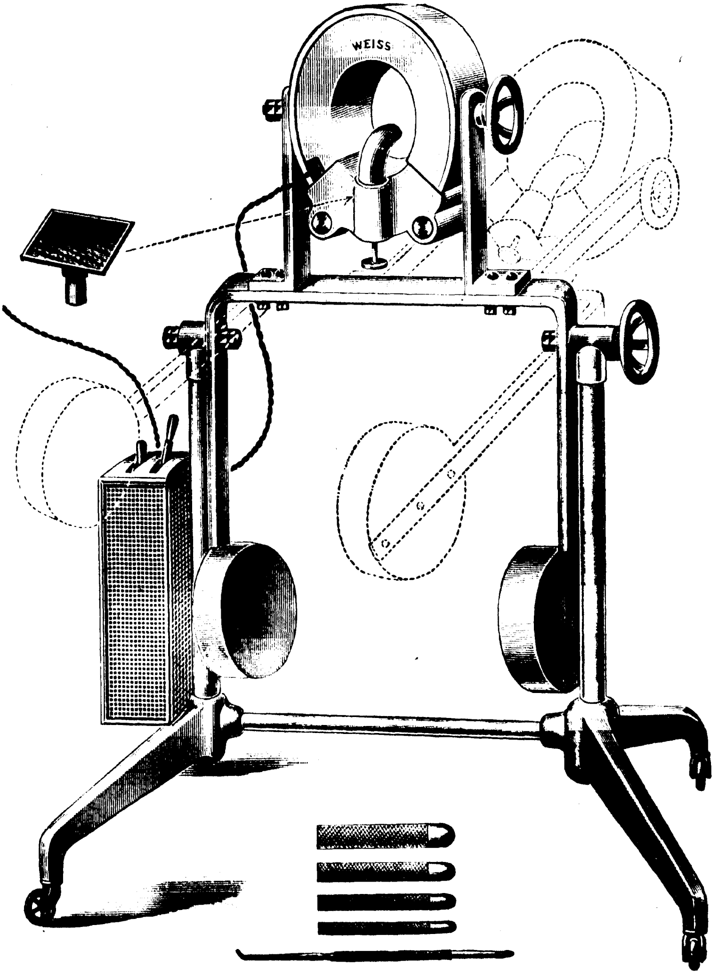

FIG. 602.—Giant ring magnet.

day or two. The course of the aqueous after the operation is indicated in Fig. 601.

REMOVAL OF INTRA-OCULAR FOREIGN BODIES

Foreign bodies of any kind which are situated anywhere in front of the vitreous-enclosing diaphragm (*i.e.* the diaphragm formed by the capsule of the lens with its continuation all round to the ciliary body as the suspensory ligament of the lens) can be removed through the anterior chamber after a corneal section ; if they are lodged in the lens their removal entails getting rid of the lens itself by one of the methods described. In the case, however, of foreign bodies behind this diaphragm, and therefore in the vitreous body, those only which are magnetisable, with very few exceptions, are capable of being removed.

THE REMOVAL OF A MAGNETISABLE FOREIGN BODY FROM THE VITREOUS

Anæsthetic.—Cocaine.

Special instruments.—A giant ring magnet (Fig. 602), a small hand magnet, and a keratome.

There are two routes of removal—(1) Through the anterior chamber after bringing the body forward by the magnet ; (2) through an incision in the sclerotic. For most cases, but not all, the former is the better method. The patient being placed on his back, the magnet is swung into position over his head so that

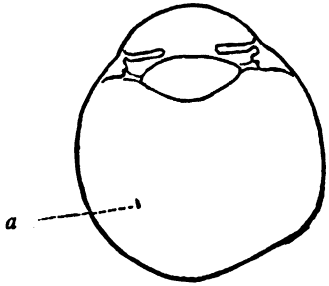

FIG. 603.—Removal of magnetisable foreign body. Stage I.
a. Foreign body.

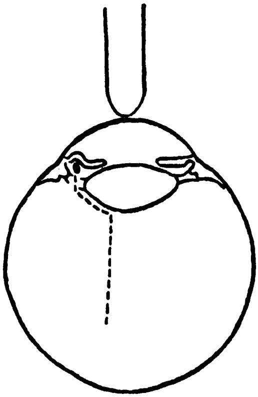

FIG. 604.—Removal of magnetisable foreign body. Stage II.

the eye is as nearly as possible in the centre of the ring. The current being switched on, the loose rods are slowly approached to the centre of the cornea, the smallest being used first and the larger ones in succession till the body comes forward. The fragment (Fig. 603, *a*) is by this means drawn forwards in the eye, slips round the convex posterior surface of the lens, comes through the suspensory ligament, and presents behind the root of the iris (Fig. 604). By means now of one of the small rods applied to the opposite side of the cornea, the fragment is drawn very obliquely through the pupil from behind the iris (Fig. 606), and is manipulated into position on the front of the iris at about three o'clock, and the giant magnet removed. A corneal section is now made above, care being taken to preserve as much aqueous as possible by keeping the point up when withdrawing the keratome. A small hand magnet is now brought up in contact with the cornea over the foreign body, and is slowly carried along in contact with the cornea to the wound. The fragment will follow the magnet on the deep surface of the cornea, and as soon as the wound is reached will slip out to actual contact with the magnet point (Fig. 607). It will be seen that no instrument but the keratome is introduced inside the eye.

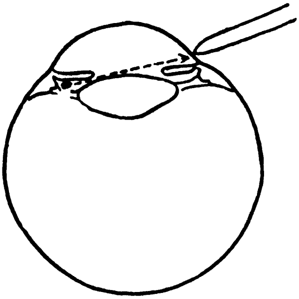

FIG. 605.—Removal of magnetisable foreign body. Stage III.

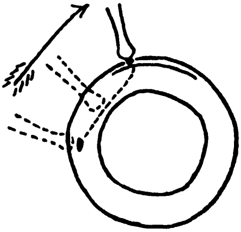

FIG. 606.—Removal of magnetisable foreign body. Stage IV.

In some cases, owing to the large size of the foreign body, or to its entanglement in the retina or choroid, the trans-scleral route is the better. The site of the foreign body can be localised quite accurately by finding the exact spot over which one of the small rods of the giant magnet causes the most pain ; this spot is noted with precision.

A general anæsthetic having been administered, the eye is fixed in the desired position by passing a stitch through the conjunctiva close to the cornea, and through the skin of the forehead, temple, nose, or cheek, as the case requires, and tying it. A rectangular flap of conjunctiva, one side of which is along the corneal margin, is reflected, so as to expose the previously ascertained site of the fragment. A von Graefe's knife is now plunged straight in at the localised spot and withdrawn, or if a larger incision seems necessary it is enlarged *as the knife is withdrawn* and not by in and out movements. If in and out movements of the knife are made, the inward movement, instead of cutting cleanly the delicate inner membranes, tend to strip them off from the sclerotic, and further, vitreous is very apt to be expressed. A flattened terminal of a small hand magnet is now introduced just within the lips of the incision, and the fragment will usually be brought out at the first attempt. The conjunctival flap is sewn into position, no attempt being made to sew up the sclerotic.

EXENTERATION OF THE ORBIT

Indication.—Malignant growths arising in the orbital tissues or extending to them from the eyeball.

Anæsthesia.—General.

Operation.—The outer canthus is split to the orbital margin. The lids, which are preserved unless involved in the tumour, are everted, and the soft tissues incised down to the orbital margin. The periosteum is divided and is stripped from the bone all round until the apex of the orbit is reached, so that the orbital contents, clothed by the periosteum, are now entirely free except for the structures at the apex of the orbit. These structures are snipped through and the bleeding arrested by gauze packing. At a later date the granulating surface is skin-grafted.

KRONLEIN'S OPERATION

Indications.—Cases where it is thought desirable to explore the orbit, or to remove an orbital tumour without sacrificing the eye.

Special instruments.—Hey's saw, mallet, chisel, bone forceps, and sequestrum forceps.

Operation.—A curved incision through the soft tissues down to the periosteum is made with the centre of its convexity just external to the outer canthus. The periosteum is incised and the bone of the outer orbital margin partly cleaned. A wedge-shaped portion of the outer wall of the orbit is now temporarily resected. The upper bone section starts just above the fronto-malar suture, the lower section commencing just above the level of the zygomatic process. These two sections are made to converge on the outer end of the spheno-maxillary fissure, and the wedge-shaped portion of bone included between them is reflected outwards and is afterwards replaced.

CHAPTER XXXIII

OPERATIONS UPON THE HYPOPHYSIS CEREBRI

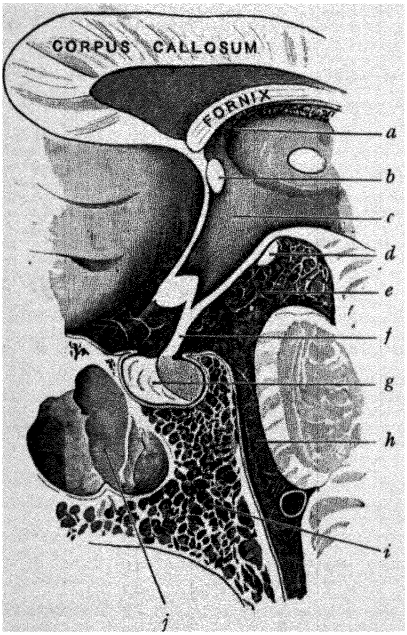

FIG. 607.—Mesial section through the pituitary region in the adult.

a. Foramen of Monro.
b. Anterior Commissure.
c. Ventricle III.
d. Corpus Mamillare.
e. Subarachnoid tissue. in cisterna basilis.
f. Infundibulum.
g. Pituitary body.
h. Cisterna pontis.
i. Body of sphenoid.
j. Sphenoidal sinus.

Hypophysis Cerebri.—The hypophysis cerebri is an oval-shaped structure consisting of two lobes—an anterior, which is derived from the epithelium of the primitive buccal cavity, and a posterior, which is developed as a downgrowth from the floor of the central portion of the cerebrum—the floor of the third ventricle. The hypophysis is connected with the basal portion of the brain by the infundibulum, which forms a connection between the posterior lobe and the tuber cinereum on the floor of the third ventricle. The hypophysis cerebri may be classed as one of the ductless glands. Pathologically it is liable to undergo considerable enlargement, in which case the resulting tumour may encroach either towards the sphenoidal sinus and the posterior part of the roof of the naso-pharynx, or upwards into the cerebral fossa (Fig. 607). The hypophysis cerebri normally occupies the pituitary fossa or the sella turcica, the hollow space within the body of the sphenoid. From its position it will be seen that the hypophysis cerebri has very important anatomical relations. Below, it is in close relation with the sphenoidal sinus and the roof of the naso-pharynx ; above, with the base of the central portion of the brain ; and laterally, with the cavernous sinus, certain cranial nerves, and the cerebral blood vessels.

Indications.—(i) A tumour in the hypophysis cerebri in cases of acromegaly. These tumours may be (*a*) adenoma ; (*b*) sarcoma ; (*c*) general overgrowth of the hypophysis.

(ii) A tumour in the sella turcica of the hypophysis cerebri which is not in connection with acromegaly. Such tumours may be (*a*) sarcoma ; (*b*) adenoma ; (*c*) tumours derived from the cranio-pharyngeal canal ; (*d*) cysts.

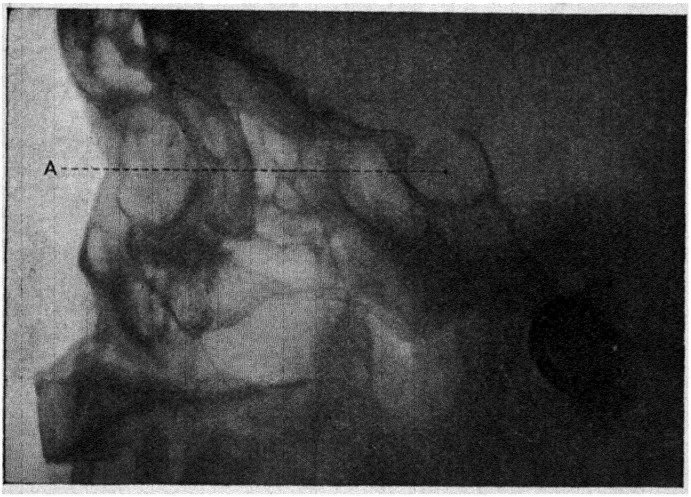

FIG. 608.—Skiagram of base of skull showing enlargement of pituitary fossa due to a tumour and encroachment upon the sphenoidal sinus.

A. Pituitary fossa enlarged by tumour of hypophysis cerebri.

In all cases of acromegaly or supposed tumour of the hypophysis cerebri or in the pituitary fossa, a skiagram should be taken of the skull, since in a fair proportion of cases the amount of enlargement of the sella turcica can be made out, which enlargement denotes generally, in the main, the size of the tumour developed within it (Fig. 608).

Route of surgical approach.—Many routes of surgical approach have been practised by different surgeons in operations for the removal of tumours of, or in connection with, the hypophysis cerebri. The two routes of approach which in my opinion are the best are (i) the trans-sphenoidal route via the nose, and (ii) the antero-lateral cranial route via the anterior cranial fossa.

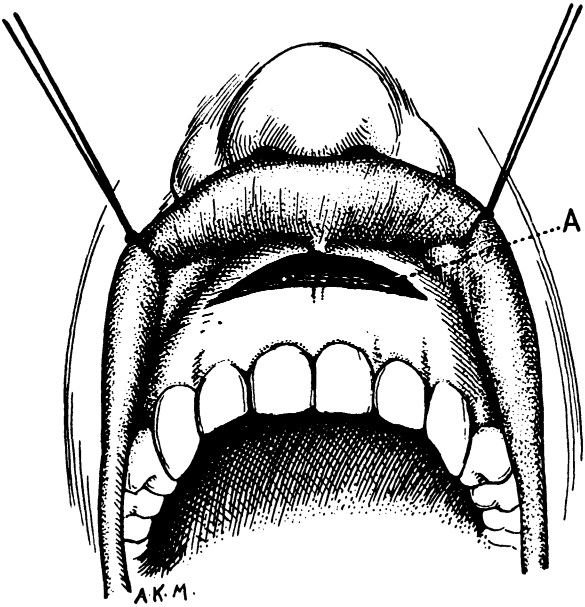

FIG. 609.—Removal of tumour of hypophysis cerebri by trans-sphenoidal operation via the nose (Cushing's operation).

A. Position of incision through mucous membrane.

(i) Removal of tumour of the Hypophysis Cerebri by the nasal route: the trans-sphenoidal operation via the nose (Cushing's operation).—

Special Instruments.—Special narrow, long-bladed nasal retractors; vulcanite dilators; long-jawed rongeur forceps; long-handled Volkmann's spoons; head mirror; Ballenger swivel knife; lateral nasal retractors and nasal speculum; long, fine sponge holders.

Position.—The patient is placed in the dorsal posture, with the head raised and somewhat thrown back. The patient is anæsthetised preferably by the intratracheal method—the tracheal tube having been introduced via the mouth and bucco-pharynx. A sponge should be placed in the posterior nares in order to plug the space and prevent the passage of any blood or other material into the upper air passages.

Operation.—

Incision and Exposure of Nasal Septum.—The patient having been anæsthetised, the upper lip is everted upwards and a transverse incision, 1½ to 2 inches in length, is made through the mucous membrane immediately below the frenum of the upper lip (Fig. 609). This incision should divide all the soft tissues right down to the bone. The muco-periosteum is then dissected upwards by means of a periosteal elevator or blunt dissector until the lower margins of the nasal apertures and the cartilaginous septum have been exposed.

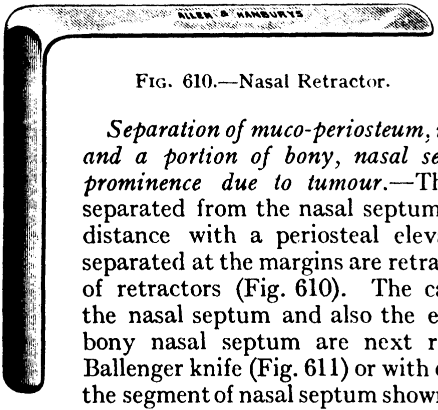

FIG. 610.—Nasal Retractor.

Separation of muco-periosteum, removal of cartilaginous, and a portion of bony, nasal septum, and exposure of prominence due to tumour.—The muco-periosteum is separated from the nasal septum on each side for some distance with a periosteal elevator when the tissues separated at the margins are retracted laterally by means of retractors (Fig. 610). The cartilaginous portion of the nasal septum and also the exposed portion of the bony nasal septum are next removed either with a Ballenger knife (Fig. 611) or with cutting forceps. When the segment of nasal septum shown in Fig. 612, both cartilaginous and bony, has been removed as far posteriorly as the base of the skull, it will be found convenient, in order to facilitate the separation of the muco-periosteum on each side, to dilate the space from which the cartilage and bone has been removed with a vulcanite or metal dilator. These dilators (Fig. 613) should be used gradually—at first comparatively small ones and then larger. By these means a considerable operative field can be made available as a result of the separation of the soft parts of the nasal septum on each side and the flattening of the turbinate bones. (In some cases where the inferior turbinate bone is very large, it may be necessary to remove a portion of the bone and the muco-periosteum covering it a short time—several days—before the performance of the main operation.)

Removal of portion of walls of sphenoidal sinus, and exposure and removal of tumour.—When the space between the two halves of the nasal septum has been dilated to give a field of operation sufficiently large, the long-bladed retractors or a suitable speculum (Figs. 610 and 614) are introduced and then the antero-inferior wall or boundary of the sphenoidal sinus is cut through and removed by either chisel and mallet, or better still, by long-bladed rongeur forceps. When the antero-inferior bony wall of the sphenoidal sinus has been removed, the tumour due to the enlargement of the hypophysis cerebri will be readily visible on sponging the bottom of the field of operation dry (Fig. 615). The mucous membrane of the sphenoidal sinus is then divided with a long-handled tenotomy knife, together with the covering of the dura mater which lies between it and the tumour. When this has been done, the margins of the incision are enlarged by passing through the opening that has been made a long pair of pressure forceps and forcibly separating the margins. The blunt spoon or scoop (Fig. 616) is now taken and the tumour removed by scooping out. When as much of the tumour as is thought desirable has been removed, the area from which it has been taken should be sponged dry and further examination made of the interior of the space. (It is usually considered advisable to remove all visible tumour with the scoop, sufficient hypophysial tissue being then left behind to perform the internal secretion functions of the gland.) After applying sponge pressure for a short time to the space from which the tumour has been taken, all hæmorrhage usually ceases.

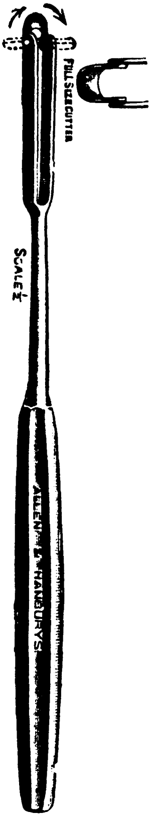

FIG. 611.—Ballenger swivel knife.

Closure of Wound.—The bi-valve speculum is next removed, and the incision through the mucous membrane of the upper lip sutured. After removal of the speculum, and before suturing, the nasal cavities should be packed with gauze wrapped up in a sheet of thin rubber well coated with vaseline. The object of passing a packing into the nasal cavities is to bring the two halves of the nasal septum into apposition and thus promote union. After the expiration of twelve hours the nasal plugs can be removed, Other methods of approach through the sphenoidal sinus have been made use of by other surgeons, such as through the palate or after turning upwards the nose. Neither of these trans-sphenoidal routes, however, in my opinion, is so satisfactory as that practised by Cushing and described above.

(ii) Removal of tumour of the hypophysis cerebri by the antero-lateral cranial route.—

Instruments.—As for temporary resection of the skull (p. 487), with the addition of blunt spoons and long-handled sponge-holding forceps.

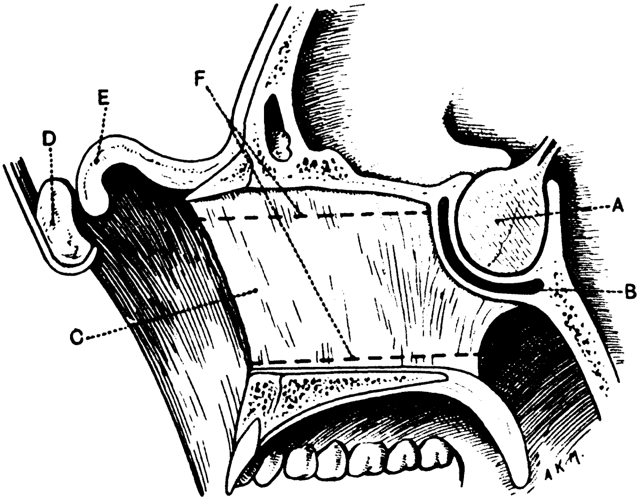

FIG. 612.—Removal of tumour of hypophysis cerebri by trans-sphenoidal operation via the nose (Cushing's operation) : showing segment of nasal septum which is removed.

A. Tumour of hypophysis cerebri.
B. Sphenoidal sinus.
C. Nasal septum.
D. Upper lip.
E. Nose.
F. Dotted lines indicating the portion of nasal septum which has to be removed.

Position.—The patient is placed in the dorsal posture, with the head turned to the left. The surgeon stands on the right, and the assistant on the left.

Anæsthesia.—Anæsthesia is best carried out by the intratracheal method.

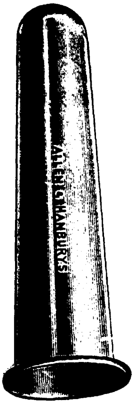

Fig. 613.—Vulcanite dilator.

Operation.—In this operation an osteoplastic flap through the cranial wall is turned down in usually the right fronto-parietal region (Fig. 617).

Incision, formation of osteoplastic flap, and exposure of tumour.—A broad ∩-shaped incision is made in the fronto-parietal region somewhat above the zygoma and in the position shown in Fig. 617. Roughly, the flap should measure 3½ to 4 inches in length, and about the same in width. All the soft structures of the scalp, including the pericranium, are divided. Next, with a periosteal elevator, the pericranium is separated from its attachment to the bone for about one-third of an inch on each side of the incision. Four trephine apertures are now made through the skull—at each lower extremity of the incision, and at each angle of the broad upper portion, in the positions shown in Fig. 617. The crowns of bone having been removed, a director of whalebone or soft copper (Fig. 617 E) is taken and the dura mater separated from the inner table of the cranial bones between the upper two openings and the ends

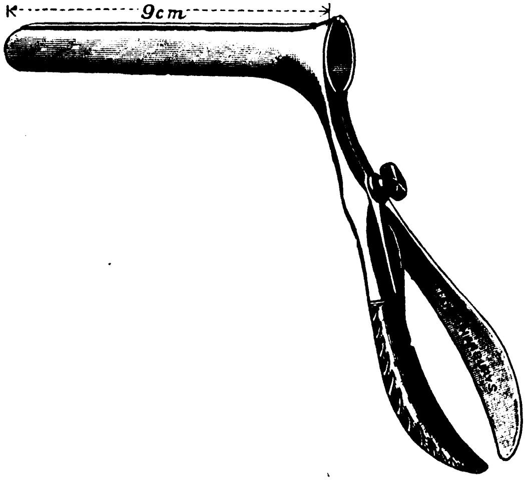

Fig. 614.—Bivalve speculum.

allowed to remain protruding. The wire of a Gigli's saw is next passed along the director, and the bone divided from within outwards between the two apertures. The soft copper director must be left in position as the bone is being cut through,

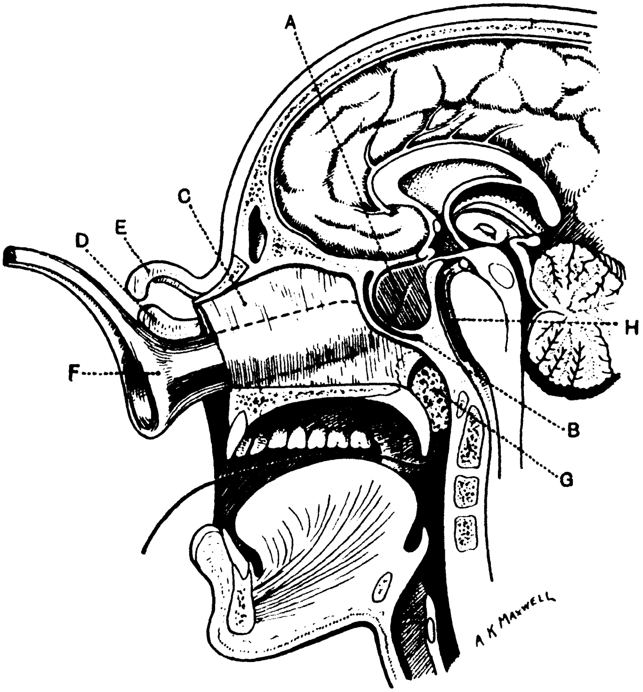

FIG. 615.—Removal of tumour of hypophysis cerebri by trans-sphenoidal operation via the nose (Cushing's operation). Method of introduction of bi-valve speculum.

A. Tumour of hypophysis cerebri.
B. Sphenoidal sinus.
C. Nasal septum.
D. Upper lip.
E. Nose.
F. Bi-valve speculum.
G. Sponge in naso-pharynx.
H. Basilar artery.

otherwise the dura mater and underlying brain may be injured. The bone should be cut through in a sloping manner, so that the divided portions of bone are bevelled at the expense of the outer table. The object of bevelling the bone in this manner is to ensure that the margins of the divided bone remain in exact apposition after the osteoplastic flap has been replaced, and not tend to be pushed inwards by the pressure of a bandage.

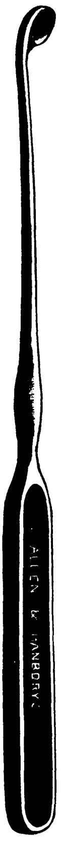

FIG. 616.—Metal scoop for removal of tumour.

A similar proceeding is then carried out on each side, and when these are completed the bone flap will only remain attached by its base in the fronto-temporal region. A strong rugine or elevator is next taken, and with it the bony flap is forcibly lifted up, fractured at its base, and turned back (Fig. 618). In old people, or people with thick cranial bones, it will usually be necessary partially to divide with the Gigli saw (Fig. 617), or mallet and chisel, the piece of bone in the base of the flap. The dura mater is detached from the internal aspect of the bony flap with a periosteal elevator as the flap is turned down. The dura mater is next divided a short distance from the line of division of the bone, and a flap turned downwards (Fig. 618, C). When the osteoplastic flap has been turned downwards, together with the underlying dura mater, the frontal lobe of brain is gently lifted upwards and inwards with soft metal wide retractors. This proceeding will expose the anterior fossa of the skull and also the anterior part of the middle fossa as far as the posterior margin of the lesser wing of the sphenoid. In the main, however, the field of operation is within the anterior fossa. When the frontal lobe has been lifted up in this way, usually the tumour in the hypophysis can be seen lying in the deepest portion of the field of operation. Carefully lifting the brain with gauze and, in some cases, packing, will enable the surgeon to get a good view of the hypophysial tumour (Fig. 618).

Removal of tumour and closure of external wound.—When the tumour has been exposed in this way the dura mater covering it is divided, great care being taken to avoid any of the main cerebral arteries, and with a blunt spoon the tumour may be removed. In some cases, however, it will be found to be friable, and the use of some form of suction apparatus is advisable. When a sufficient amount of the tumour has been removed, the area from which it has been taken is sponged dry and the brain allowed to fall back into its former position. The flap of the dura mater is then replaced and sutured; and afterwards the osteoplastic flap is put in position and also sutured. Drainage is usually not necessary.

The intracranial route of approach is indicated especially in those cases in which either from appearances seen in the skiagram or from clinical symptoms it is thought that the tumour has encroached considerably on the cranial cavity. This operation is not so suitable for those cases in which the main portion of the tumour is in the pituitary fossa, and this space is enlarged so as to form an extension downwards and forwards in the body of the sphenoid and encroaching on the sphenoidal sinus. Other methods of approach through the skull wall have been practised. In my opinion, however,

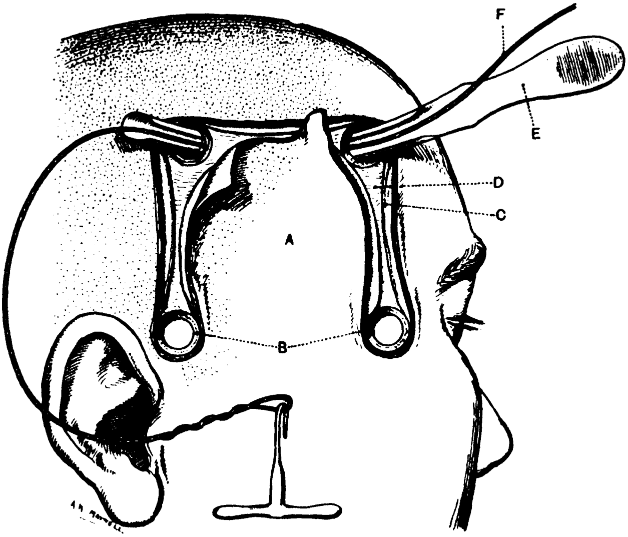

FIG. 617.—Removal of tumour of hypophysis cerebri by the anterolateral cranial route. Method of formation of osteoplastic flap.

A. Osteoplastic flap.
B. Lower trephine apertures.
C. Divided periosteum.
D. Position of division of bone by Gigli's saw.
E. Whalebone protector.
F. Gigli saw.

this method is the best when it has been decided that the route of surgical approach should be via the convex portion of the skull wall.

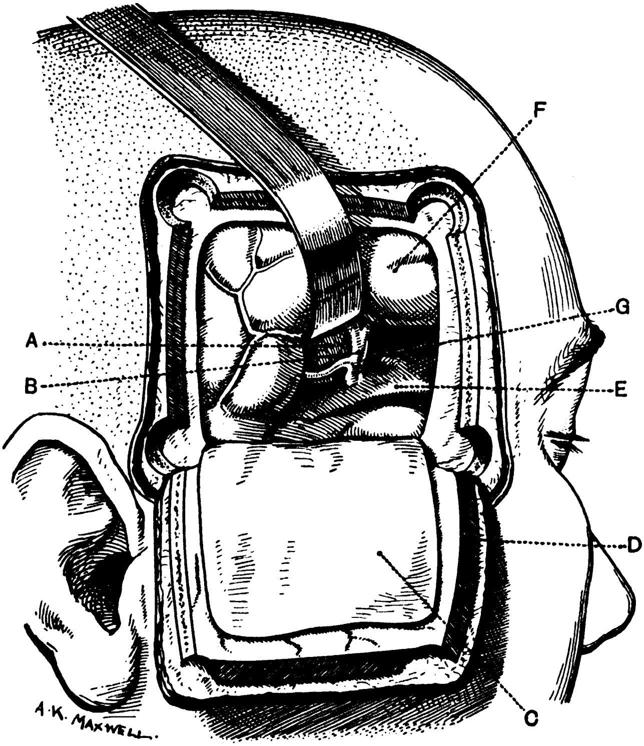

FIG. 618.—Removal of tumour of hypophysis cerebri by the antero-lateral cranial route: showing osteoplastic flap and dura mater turned down, brain lifted up, and tumour exposed.

A. Tumour of hypophysis cerebri.	D. Bevelled bone.
B. Anterior cerebral artery.	E. Anterior clinoid process.
C. Osteoplastic flap and dura mater (turned down).	F. Frontal lobe of cerebrum.
	G. Optic chiasma.

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